THE TECH ENGINEERING NEWS

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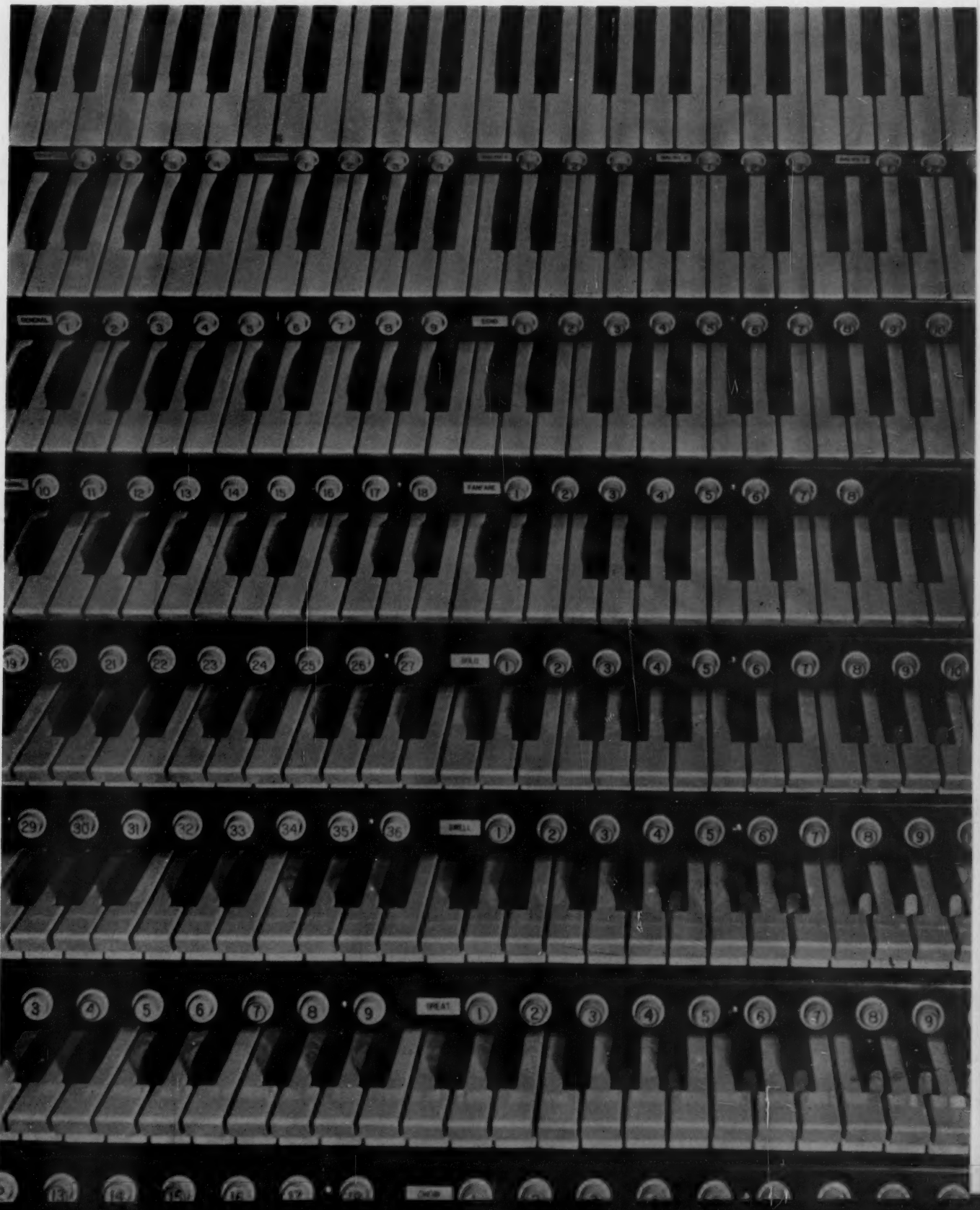

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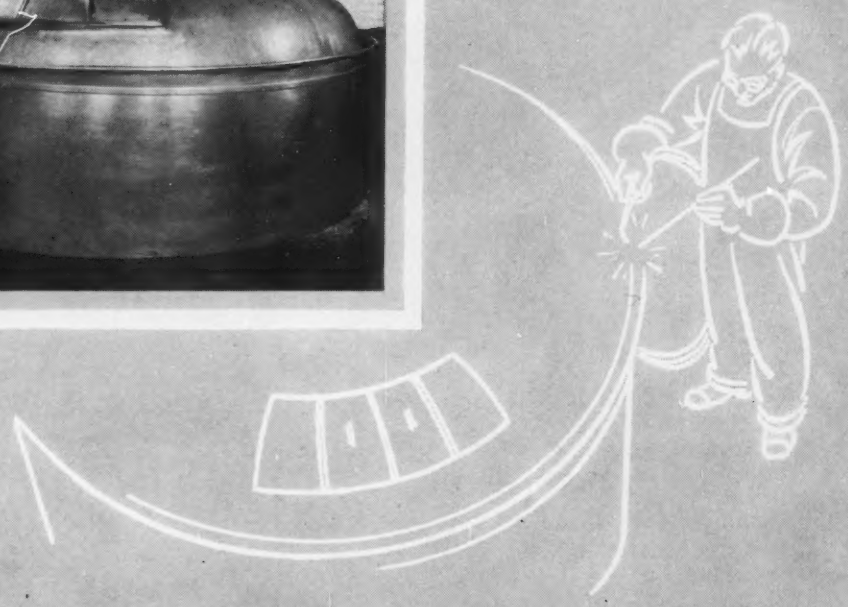

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OUR AUTHORS

KARL TAYLOR COMPTON, President of the Massachusetts Institute of Technology, is the co-author of *The Engineer In Industrial Relations*. He was born in September, 1887, in Wooster, Ohio, and later attended Wooster College there. From Wooster College he received two degrees: his Ph.B. in 1908, and his Sc.M. in 1909. In 1912 he was awarded a Ph.D. degree from Princeton. He is a member of Alpha Tau Omega, Phi Beta Kappa, and Sigma Xi, and holds numerous honorary degrees from educational institutions throughout the nation, among which are Harvard, Princeton, and the University of Wisconsin. Since 1930 he has been the President of Technology, and in 1931 won the Rumford Medal for his contributions to the fields of spectroscopy and thermionic emission. He is the Chairman of the Division of Physics of the National Academy of Science, and is the author of more than 100 publications.

W. RUPERT MACLAURIN is the co-author of *The Engineer In Industrial Relations*. He received his A.B. degree from Harvard in 1929, attended Trinity College in Cambridge, England, as a Fiske Scholar in Economics in 1929 and 1930, and later returned to Harvard, where he earned an M.B.A. degree in 1932, and a D.C.S. degree in 1936. Since then he has been an Assistant Professor of Economics at the Massachusetts Institute of Technology. Mr. Maclaurin was born in Wellington, New Zealand, and is the oldest son of the former President of the Institute.

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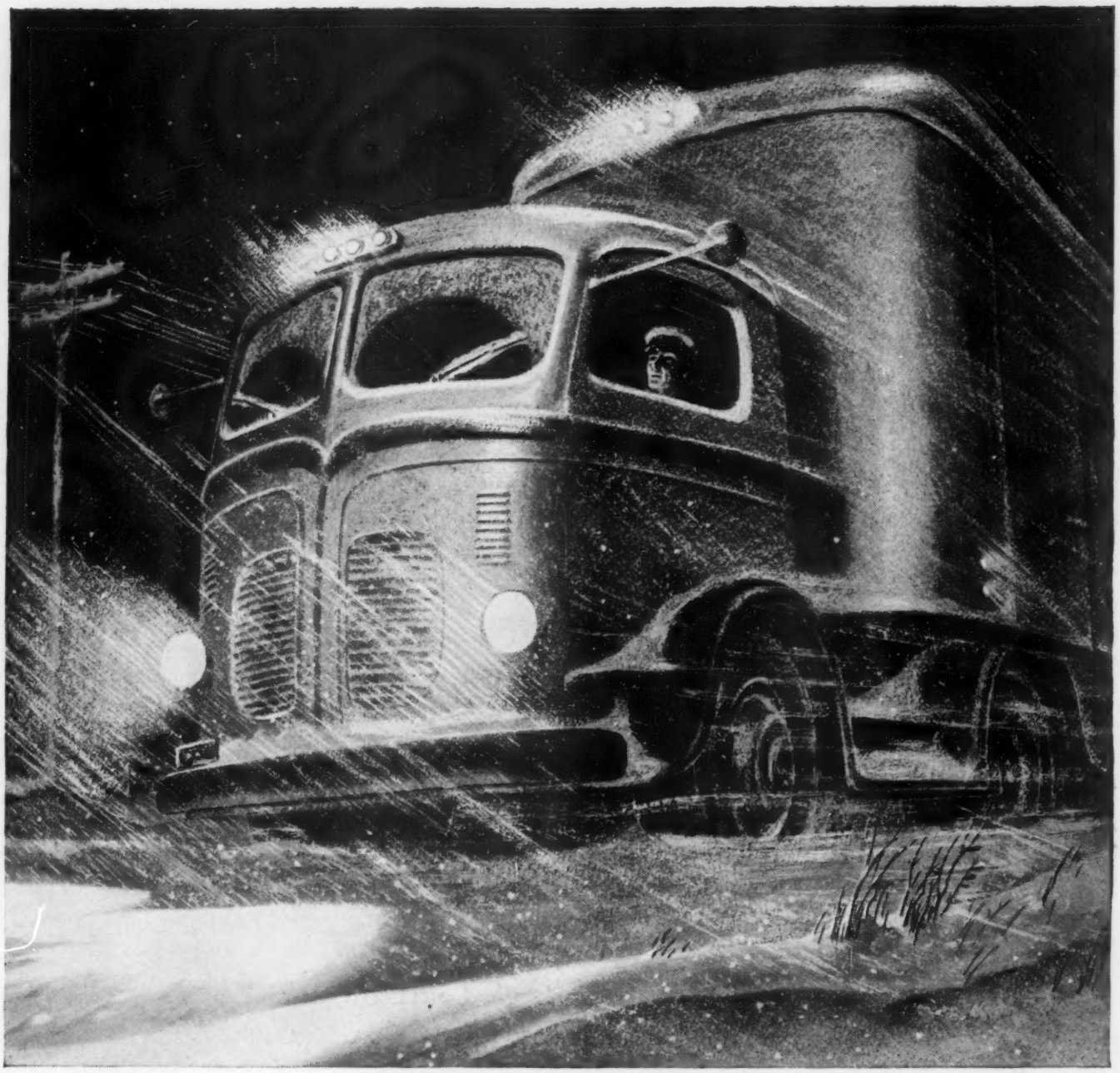

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Contents for December

THE ENGINEER IN INDUSTRIAL RELATIONS - - - - - by KARL T. COMPTON and W. RUPERT MACLAURIN 173
ELECTRONICS IN MUSIC - - - by WILLIAM G. PECK - - - - 176
THE IRON LUNG - - - - by WARREN E. COLLINS, JR. - - - 178
WELDING OF ALLOY STEELS - - by MILTON MALE - - - - - 180
THE FLYING FORTRESS - - - by ERLING H. HUSTVEDT - - - - 183

Editorials

SEX EDUCATION - - - - - - - - - - - 184
AN ANNIVERSARY - - - - - - - - - - 185
SALESMAN OF DEATH - - - - - - - - - 185

Research in Review

ULTRA-HIGH FREQUENCIES (Course VI) - - - - - - 186
SYNTHETIC ALCOHOLS (Course V) - - - - - - - 186
RADIOACTIVITY (Course V) - - - - - - - - 187
NEW COURSES (Course IX) - - - - - - - - - 187

Engineering Digest

STEEL WIRE MILL - - 188
OXY-ACETYLENE HARDENING 188
ELLIPTICAL GRINDING - 189
ELECTRICALLY WELDED TRACKS 190
DIPHONIC SPEAKER - - 190
MAMMOTH CUTTING TOOL 191

THIS MONTH'S COVER AND FRONTISPIECE

The cover plate of this issue is a closeup of the seven keyboards, and the frontispiece shows a little of the pipework, of the World's largest Organ. This instrument is installed in Convention Hall, Atlantic City, an auditorium seating 41,000 people. It was designed by Senator Emerson L. Richards. The organ has a total of 33,000 pipes, and the blowing equipment totals 404 horsepower.

—Courtesy *The American Organist*

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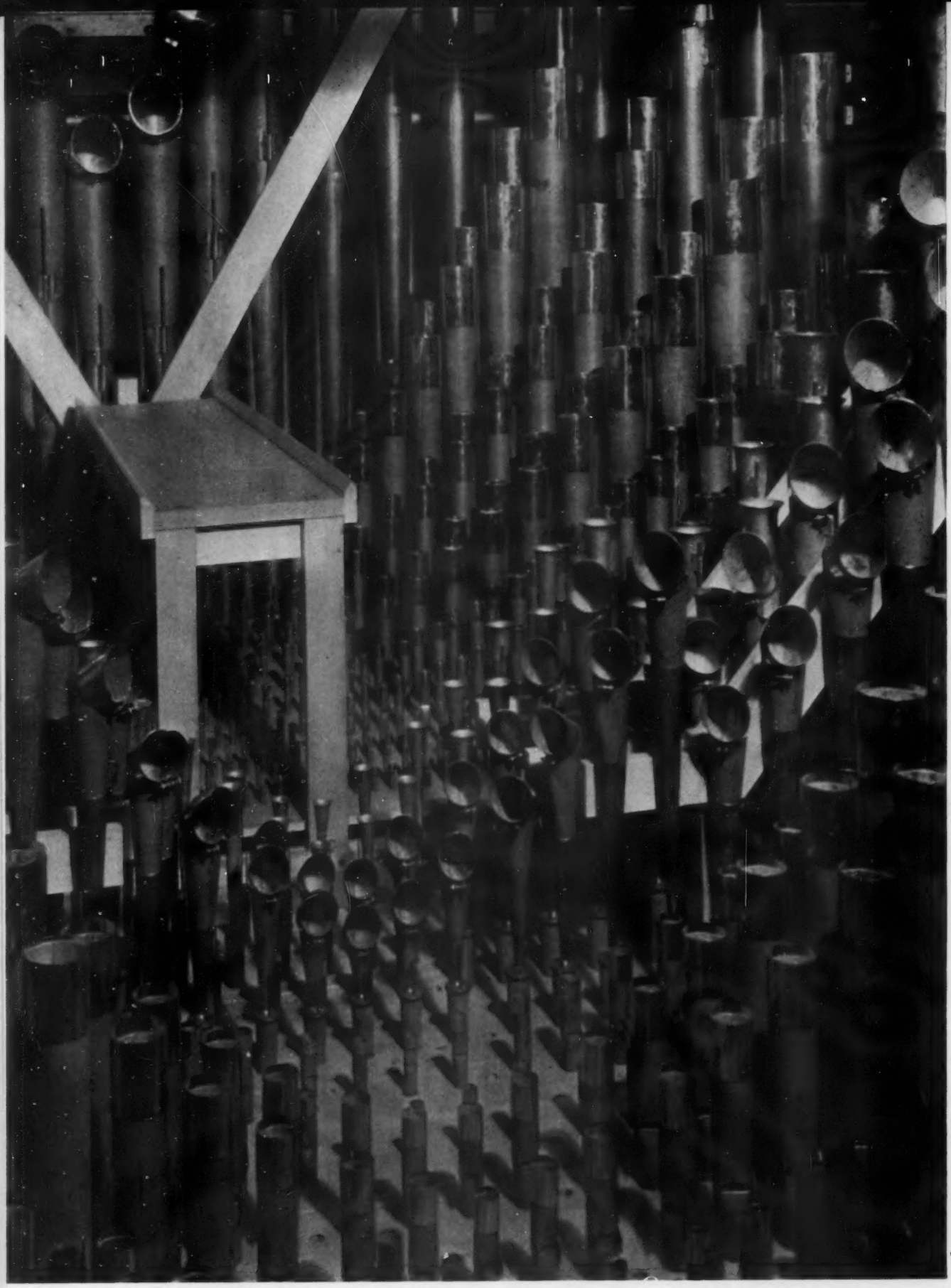


METAL THROATS

THE ENGINEER IN INDUSTRIAL RELATIONS

I-Why the Engineer Has An Interest in Industrial Relations

KARL T. COMPTON

THE place of the engineer in industrial relations is an interesting subject. It is a particularly appropriate subject for discussion at the present time because a number of organizations and individuals in New England and elsewhere, who foresee the increasing importance of sound programs of industrial relations to the future welfare of industry and society at large, have approved and aided the establishment of an Industrial Relations Bureau at the Massachusetts Institute of Technology, the purposes of which are education, research, and dissemination of information on industrial relations, with special reference to the situation in New England. My colleague, Professor Maclaurin, who will be in immediate charge of this bureau, will describe in more detail its origin and objectives.

Why does the engineer have an interest in industrial relations? His interest is far more than that of the average citizen, for to a large extent he shares with the employer an interest and responsibility, in virtue of his special connection with industrial relations problems. Let me explain this special connection from three points of view.

In the first place, it is a fact of experience that men trained as engineers have much more than average likelihood of finding themselves ultimately in those high positions in industry which give them peculiar responsibilities for determining industrial relations policies. I might attempt to present logical reasons for this, but the facts seem to speak for themselves. In a recent address before the Boston Conference on Distribution, I discussed this subject, quoting statistics from a personnel survey of American industry by the Director of the General Motors Institute of Technology, supplemented by pertinent census statistics. In that particular branch of business designated as industry, as distinguished from other branches of business like finance or distribution, these statistics indicated that a man trained in an engineering school is twelve times more likely to be found in the presidential position than if he had attended a non-engineering college; he is five times as likely to be treasurer; thirty times as likely to be in production; 174 times as likely to be in engineering; and twenty-four times as likely to be in sales. Grouping all offices together, an engineering college graduate is thirty times as likely to find himself an officer in American industry as is a graduate of a non-engineering college. These facts, obtained from a survey of 50,000 officers in American industry, show that engineers have a relatively large share of responsibility in determining industrial relations policies. They indicate also that our engineering schools are not doing their full duty in training their students to grapple with important problems that will later confront them unless they include in their educational program some studies which will give a basis of sympathetic and constructive understanding of the problems of industrial relations. It is this fact that has impelled us at the Massachusetts Institute of Technology to introduce some special studies and facilities in this field. These have been introduced primarily for their educational value in the training of young men who will later become officers in American industry. A necessary by-product of this work, if it is wisely carried on, will be opportunity from time to time to serve those who are faced with practical problems in industrial relations along lines which Professor Maclaurin will suggest in the second part of this article.

A second reason for the engineer's special interest in industrial relations arises from his responsibility for the various developments which underlie the whole field of industry and its problems. His invention or perfection of new machines is responsible for technological unemployment. The same activities are responsible for the creation of new industries and new employment. His work has brought about the higher standard of living, in a material sense, which has been realized in every group of our population, all the way from the physically or mentally unfit, who are cared for in our institutions, clear through to the group of productive workers, whether they be primarily laborers of brawn or brain. The engineer is principally responsible for increased productive power and the resulting higher profits which are shared alike by workmen in their wages, owners in their profits, and the public in reduced cost of goods. I have seen nowhere a more effective brief summary of the favorable aspects of our technological age than that which recently appeared in a bulletin on fundamental trends distributed by the First National Bank of Boston, in its initial chapter entitled "The American System and the Abundant Life."

On the other hand, we all admit the serious problems which have accompanied this technological progress. In the October issue of the *Tech Engineering News* is an interesting brief article by Mr. John L. Lewis in which he emphasizes two features of technological progress which greatly concern the laboring man. Admitting that technological progress on the

whole has created more employment than it has destroyed, he points out the very pertinent fact that this in itself does not solve the problem for the individual laborer who is thrown out of work by some technological change. He also points out the psychological effect of uncertainty and fear which is created by such instances and which spreads through the whole laboring group and leads them through mass action to seek a higher degree of security. Among several illustrations which he gives, I quote the following: "Witness, for instance, the recent introduction of automatic continuous rolling mills in certain steel plants. These mills employ practically no labor, and their emptiness of human beings is a constant reminder to the workers in other mills of what may happen to them."

When we realize the importance and complexity of these problems and the intimate way in which the engineer is associated with them, it is immediately evident that he not only has a legitimate interest in the solution, but has a real responsibility for leading in the search for wise solutions.

The third reason for the engineer's interest in industrial relations is of a less direct and more philosophic nature, but fundamentally I believe it to be of even more importance than the two aspects of his responsibility to which I have already called attention. I refer to the present trend in political thought which has been so ably discussed by Walter Lippmann in his recent book "The Good Society." I cannot introduce this subject more effectively than by quoting a couple of paragraphs from his chapter entitled "The Dominant Dogma of the Age."

"Although the partisans who are now fighting for the mastery of the modern world wear shirts of different colors, their weapons are drawn from the same armory, their doctrines are variations of the same theme, and they go forth to battle singing the same tune with slightly different words. Their weapons are the coercive direction of the life and labor of mankind. Their doctrine is that disorder and misery can be overcome only by more and more compulsory organization. Their promise is that through the power of the state, men can be made happy.

"Throughout the world, in the name of progress, men who call themselves communists, socialists, fascists, nationalists, progressives, and even liberals, are unanimous in holding that government with its instruments of coercion must, by commanding the people how they shall live, direct the course of civilization and fix the shape of things to come. . . . . .

"So universal is the dominion of this dogma over the minds of contemporary men that no one is taken seriously as a statesman or a theorist who does not come forward with proposals to magnify the power of public officials and to extend and multiply their intervention in human affairs."

Continuing in his next chapter entitled "The Gods of the Machine" he goes on to say, "The current return to the authoritarian principle in politics finds its principal sanction in the belief that the new machine technology requires the control of an omnipotent state. There are many versions of this basic idea. By some it is said that only the strong arm of government can protect men against the brutal oppression of their machines; by others that only the power of government can realize the beneficent promise of the machines. But all agree that in the recent progress of technology there is some kind of deep necessity which compels mankind to magnify the sovereignty of officials and to intensify their intervention in affairs. The modern state holds its sovereign power by grace of the gods of the machine." These tendencies, so aptly phrased by Mr. Lippmann, are the most powerful and may be the most dangerous movements in the world today, whether they be considered from the international viewpoint, or on the basis of the internal economy of our own nation and the political life of its citizens. Note that the movement toward greater control by the state, permeating not only corporate industry but also the freedom and initiative of individual citizens, is a reversal of those recent centuries of progress which has culminated in democratic government and whose basic objective and greatest triumph has been the increasing protection of the individual against regimentation and coercion by the government. There is grave danger that the great triumph in setting up a government "of the people, by the people and for the people" is being replaced by a government "of the people, by the government and for the government." In proportion as this comes to pass, we will have lost the emphasis on individual liberty and initiative and rights of minorities, which all agree have provided the environment responsible for the remarkable progress in material welfare, education, and satisfaction in living which have marked the last two centuries of Occidental civilization.

The engineers have a peculiar interest in this situation, because it has been the protection of individual initiative and freedom of thought which has enabled them to make their recent contributions to human welfare. The authoritarian state is not a modern invention. As Walter Lippmann points out, it was practiced by the Pharoahs, by the Byzantine Emperors, by Louis XIV, by the Hapsburgs, and the Romanoffs. Regulation of industry by the state was never more minute than in the stagnant days preceding what we call the Renaissance and the Industrial Revolution. Both the state and the great guilds, which were the predecessors of the modern labor unions, established regulations in great detail which had the effect of, and were probably designed to maintain the status quo. In the textile industry, for example, in the 17th and early 18th centuries there were rigid regulations regarding the width of reeds and number of threads in which fabric could be woven in every textile center of Europe. When, in 1718, it was discovered that a certain town in France had been overlooked in this regimentation, an edict was published stating that "His Majesty is informed that no regulation specifies from how many threads those cloths are to be composed, a matter which must be attended to without fail."

It is obvious that no technological progress and therefore no contribution by engineers to further improvement in our standard of living can be possible in such a situation, and engineers therefore view with great alarm the tendency of the past few years to revert to regimentations and regulations sponsored by government, and by agreements within industries, and between industry and labor, which tend to crystalize the status quo and stifle further progress.

It is our hope that a clear understanding of these dangers and an intelligent cooperative effort, sponsored jointly by the most enlightened conditions in industry, in labor, and in the engineering profession, can find the necessary solutions to problems of industrial relations, without going to those extremes which will stifle further progress of civilization for the sake of finding an easy and arbitrary solution to some of our existing difficulties. This is a basic reason for the interest of engineers generally in the subject of industrial relations, and of the Massachusetts Institute of Technology, particularly in its present effort to sponsor an Industrial Relations Bureau. We realize the importance of the problems; we are anxious to do what we can to aid in their solution both now and in the future; and we are extremely anxious that the solutions adopted shall not undo what the engineers have done in the past and can do in the future for the advancement of human welfare.

For these reasons we were greatly interested when the suggestion first came to us that we should establish in New England a labor relations bureau somewhat along the lines of those recently established in several other educational centers in this country and Canada. Before following this suggestion, I made some investigation of the success of these earlier bureaus and of the reputation in which they were held by industrial and labor groups in whose judgment I had confidence. Being reassured by this investigation, we have proceeded to lay

plans for an Industrial Relations Section in our Department of Economics and Social Science, and to seek the necessary financial support for conducting this Section during a trial period of five years. I am happy to announce at this time that the cooperation and the contributions toward this project from over fifty of the leading industrial organizations of the country have assured us of the necessary support to carry through this effort. This bureau will be in the immediate charge of Professor W. Rupert Maclaurin, who has had some actual industrial experience, who has received his advanced training at the Harvard Business School, and who, among his other achievements, has made an exhaustive study of the economic rehabilitation and the industrial relations movements in recent years in Australia, a country which already has passed through many phases of our present American industrial situation. I have asked Professor Maclaurin to join me in my discussion of this subject, and he describes below something of the background and plans of our Industrial Relations Section.

II-What the Industrial Relations Section of M. I. T. Hopes to Do

W. Rupert Maclaurin

THE development of specialized departments for the study of industrial relations in universities dates back some fifteen years and owes its inspiration to Mr. C. J. Hicks who was at that time in charge of industrial relations for the Standard Oil Company of New Jersey. Because of his intimate knowledge of industrial relations, not only in the Standard Oil of New Jersey, but also in many of the other leading companies of the United States, Mr. Hicks was invited from time to time by Harvard, Yale, Princeton, and other universities to address their classes in labor. In visiting these colleges Mr. Hicks was impressed by the fact that for one reason or another their labor courses took little or no account of the actual practice being followed by some of the leading companies in the United States in employer-employee relations. The difficulty, as he saw the problem, lay principally in the fact that the professors in charge were not given the time or the money to permit them to keep in close contact with current developments in the field of industrial relations. In discussing this question with Professor Kemmerer, the head of the Economics Department at Princeton, Mr. Hicks suggested that it should be possible to build up an industrial relations library of current as well as historical material similar to the library that Princeton already had in corporation finance. As it had proved possible at Princeton to teach corporation finance from a practical standpoint on the basis of material collected and available to both professors and students in a specialized library in corporation finance, Mr. Hicks believed that it should be possible to handle the course on labor in the same fashion.

As a result of this suggestion, it was decided to establish a new section of the Department of Economics which would specialize in the field of industrial relations, keep in close personal contact with actual developments in the field, and write reports of current interest and significance to business men, government officials, and labor organizations. John D. Rockefeller, Jr., agreed to finance the program for an initial five-year period and at the end of that time, the section having proved its value, Mr. Rockefeller endowed it. This was in 1925. Since then the Princeton Industrial Relations Section has become very well established. During the last three years the Section has received nearly seven hundred specific requests for information and material. While about one-half of these requests have been taken care of by sending mimeographed or printed memoranda previously prepared, the remainder have required additional research to prepare answers.

The success of the Princeton Section has resulted in the spread of the movement in recent years. It was found that while Princeton was able to keep in touch with a substantial number of national concerns outside the New York, New Jersey, and Pennsylvania area, it was able to perform its principal service to industry in these three states only. It was Mr. Hicks' hope, therefore, that similar sections might be established in five or six key institutions in different parts of the United States. Two years ago the University of Michigan decided to follow Princeton's lead by setting up a specialized Industrial Relations Section. A little over a year ago a section was also established at Stanford University in California, and another section has more recently been established at Queens University in Canada. All of these extensions of the Princeton plan, including M.I.T., have been undertaken at Mr. Hicks' suggestion and with his cooperation.

The new section which we are organizing in the Department of Economics at the Massachusetts Institute of Technology to specialize in the New England area is the latest move in this development. While each of the sections will undoubtedly develop along somewhat different lines, the Technology Section will function in close cooperation with those already in existence, benefiting from their experience and making use of the information they have compiled.

We plan to build up at Technology a first class library of current material in the field of Industrial Relations. This will require the cooperation of industrial, governmental, and trade union organizations. We hope, for example, to collect from the leading industrial concerns in the United States all the material which they have available on industrial relations questions. This will involve the collection of pension plans where they exist, written labor policies, collective bargaining

(*Continued on page 192*)

Electronics In Music

The Vacuum Tube Has Found a New Use

WILLIAM G. PECK

DURING the past three years, a new type of musical instrument has been placed upon the market and has met with commercial success. Since the tone produced by these instruments resembles that of the organ, they are commonly known as "electric organs"; for this and other reasons they have been placed under the control of a console, similar, and in some cases exactly equivalent, to that of a genuine organ. There has been some dispute, however, as to whether these instruments might correctly and properly be called organs. A more accurate name which has come into considerable use among organists is "electrotones," and it is by this name that they will be referred to throughout this discussion.

Most people have, at best, a rather hazy concept of the many interesting details involved in these instruments, although they have come into quite general use in broadcasting studios, dance orchestras, and some churches. There are at present two companies in the United States manufacturing them—the two instruments being called the *Hammond Electric Organ* and the *Orgatron* respectively. In Germany the Welte Organ Company is manufacturing a device called the *Welte Photolone*. These three instruments will be described and analyzed here, because they represent those applications of electronics to the production of music which have proven to be commercially practicable.

The first electrotone to reach the public as a standardized instrument which could be bought for a reasonable price was the Hammond. During the few years since its introduction it has sold well, and recently has been considerably improved. It was conceived and developed by Mr. Laurens Hammond of the Hammond Clock Company, and is probably the most interesting, from a scientific point of view, of the three instruments under discussion.

The principle of tone production is, in itself, quite simple, being the actual production of tone colors of various sorts by mixing fundamentals and harmonics in various proportions of intensity. How to do this economically and with a reasonable degree of perfection is another story, however. The basis of the system devised by Mr. Hammond is the small alternating current generator pictured in Figure 1. From a set of ninety-one of these, all geared to a synchronous motor, the fundamentals for the complete musical range of the instrument are derived.

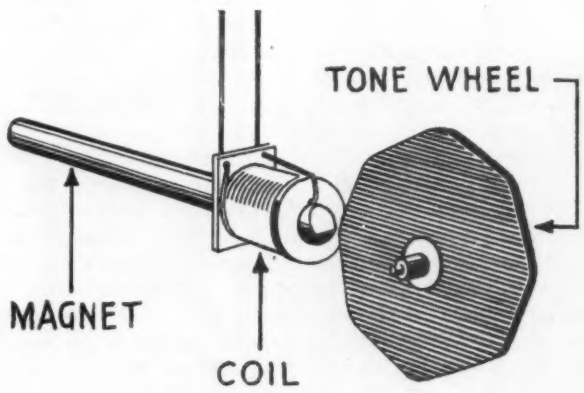


Figure 1—Tone Generator

Let us consider the operation of one of these generators The disc with the irregular edge is made of steel and is called a tone wheel. Rotating at constant speed, the high and low points (teeth) on its edge cause a regular fluctuation in the magnetic field between it and the end of the permanently magnetized rod, which, together with the coil wound on it, is the stator of the generator. This fluctuation causes a very small alternating current to be set up in the coil on the bar. The teeth are cut in such a shape that the alternating current produced is almost exactly sinusoidal; and herein is one of the major difficulties encountered in the production of synthetic tone—the production of a series of pure sinusoidal alternating currents. The difficulty has been practically overcome here by proper cutting of the wheels, coating both members of the generator with lacquer to prevent changes in shape by oxidation, and providing each generator with a small filter circuit to eliminate stray harmonics.

The arrangement of these ninety-one generators is interesting. In the standard musical scale there are twelve semitones to the octave, and in this generator assembly there are twelve speeds geared from the synchronous motor—one for each semitone. Each of seven of these twelve speeds operates a group of eight generators, and the remaining five operate seven generators plus a blank, which is put in to maintain mechanical balance. All of the generators operating at a given speed are octaves of each other, a fact that allows the use of eight different cuts of tone wheel—one of two teeth, one of four, one of eight, one of sixteen, etc. A set of these, revolving at one of the twelve speeds, produces all of the A's of the instrument; another set at a different speed produces all of the B's; another set produces all of the C's, etc. Each of these sets is shielded from the others by steel plates to prevent mixing of frequencies by induction.

Let us trace the current from one of these generators through its rather complex path to the loud speaker, where it finally becomes a component of a musical sound. It must be kept in mind that the frequency supplied by one generator, say 440 cycles per second, is a fundamental frequency for one note (A in this case), and also a harmonic frequency for several other notes. For instance, it is the first harmonic of the A one octave below 440 cycles per second. Each generator, therefore, is wired to one of nine contacts under the key of which it is the fundamental frequency, and to a contact under each of nine other keys of which it is a harmonic. So each key has nine generators wired to it: its fundamental, and six of its harmonics, its sub-fundamental (one octave lower than fundamental), and one harmonic of the sub-fundamental. When the key is depressed, contact is made with wires from nine sliders (Figure 2), each of which makes a series of connections with eight taps on the primary of a matching transformer. This gives eight degrees of intensity for the fundamental and each harmonic, so that a wide variation in the relative proportions of the fundamental tone and each harmonic is provided. Let us look into the process by which tone colors are synthesized. The secondary of the matching transformer is connected through a volume control to the input of a pre-amplifier. From here, the mixture of frequencies is sent to one or more twenty-watt power amplifiers, depending on the size of the room in which the instrument is to be heard, and upon the acoustical conditions to be met with.

Each twenty-watt amplifier is equipped with two twelve-inch speakers. The power amplifier circuit is such that it draws no current from the pre-amplifier output, so that practically any number of the power amplifiers may be used. In a recent outdoor concert something like ninety of them were attached and successfully operated.

The mechanical and electrical makeup of the instrument is beautifully executed, and the way in which various engineering problems have been overcome is, in some cases, ingenious. There are, however, certain fundamental difficulties that have not yet been conquered. One of them is that the set of ninety-one generators must be tuned to what is known as a tempered musical scale. The process of tempering and the reasons for it are too complex and lengthy to go into here. Suffice it to say that because of a certain incompleteness in the musical scale which is universally used, the fifths (the interval between middle C and the G above it is a fifth) must be tuned so that they are not quite the exact mathematical multiples that they normally are. The same must be done to certain other intervals in the scale. Whether you understand this or not, you should be able to understand the condition which results in this electrotone. The condition is simply that some of the harmonics in the instrument (those that are not octaves of their fundamental) are not exact mathematical multiples of the fundamental with which they are mixed, and therefore do not exactly jibe with it. Because of this, the tone color produced is not a perfectly true one. The difference is not noticeable to the casual or untrained ear, and could be remedied by the use of additional sets of generators to supply the needed harmonics; but the expense involved would be prohibitive at present.

Another difficulty is that the full number of harmonics in a rich tone color runs into the thirties, whereas here only eight are supplied. This is not really so bad as it first seems, for the harmonics supplied are the principal ones which affect the ear. The absence of some of the remaining twenty-odd tones would make no appreciable difference in a tone color, but the complete absence of all of them causes the tone to lack a certain amount of richness which it otherwise would have. Here again the cost of supplying these additional harmonics would be prohibitive, and would make the construction and operation of the instrument considerably more complicated than practical limits allow. Some of the advantages of this electrotone over others will be discussed later on.

The second electrotone to be discussed was developed from an idea which has entered the mind of more than one scientist,

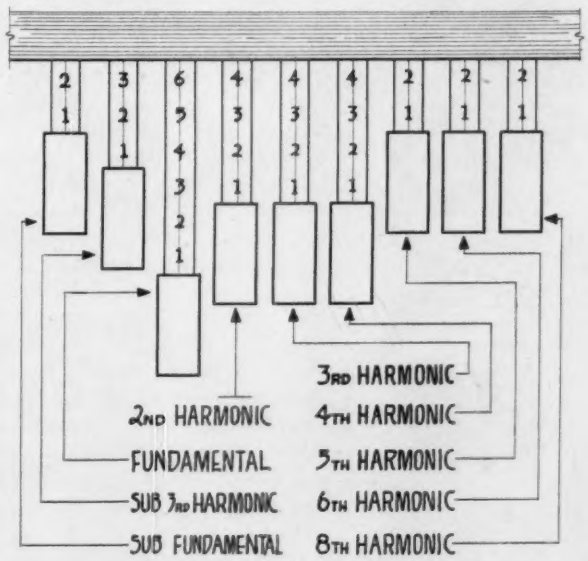
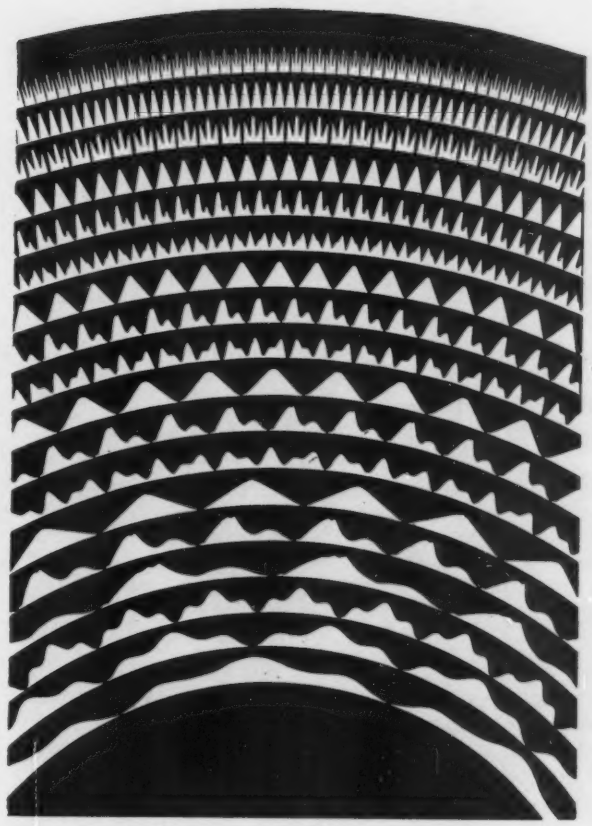


Figure 2—A Harmonic Controller



—Courtesy The American Organist.

Figure 3 — Tone Disc.

an illustration being the instrument constructed at the Institute some seven years ago under the direction of Professor Arthur C. Hardy of the Physics department. The basis of this method of tone production is the periodic regulation of a light beam falling on a photo cell. The electrical variations thus produced are amplified and transformed into sound. The first man to develop this idea sufficiently to make a practical model was Mr. Edwin Welte, an organ manufacturer of Freiburg, Germany. He calls his product the *Photolone*. Such a method of tone production does not seem to involve the extensive engineering problems presented by the Hammond idea, although its development was by no means easy.

The process of regulating the light beam is, of course, the only real problem in the process. It might best be put in this way. Given: a large number of light-beam photo cell assemblies, suitable amplifying equipment, and one or more keyboards through which the photo cells may be connected to the amplifier. Wanted: a practical, inexpensive, foolproof method of regulating the light beams to produce a number of different tone colors, each tone color being available as a complete musical scale of sixty-one notes (five octaves, the standard range of an organ keyboard). The method adopted by Mr. Welte consists of recording various wave forms on concentric tracks on a large glass disc, and rotating the disc between a bank of photo cells and a bank of corresponding lights, so that each light beam is separated from its corresponding cell by one of the tracks.

The method of recording these wave forms on the disc is an interesting problem. Oscillograph records of actual sounds produced by various instruments (in the case of the *Photolone*, the various tone colors of a pipe organ) are mathematically analyzed, and the resulting equations changed over to polar

(*Continued on page 196*)

The Iron Lung

A Successful Tool For Fighting Infantile Paralysis

WARREN E. COLLINS, JR.

ONE of the most interesting aspects of present-day engineering is the increasing relationship it has with medicine. Within the last few decades there has been a distinct tendency to adopt scientific procedures in the study and practice of medicine. This has included the integration of engineering and physiology in the study of the effects, and in the advancement of the control of physical agencies in both the treatment and prevention of disease.

An excellent illustration of this interplay of medicine, physiology, and engineering is found in the Drinker respirator, or "Iron Lung," which has become better known and understood than perhaps any other recent mechanical device used in medicine. Its very name associates it with one of the country's foremost institutions, in which physiology and engineering proceed hand in hand toward the study and control of man's physical environment with his increasing welfare and comfort as the goal. This is the School of Public Health of Harvard University, which is administered jointly by the schools of engineering and medicine of the University.

The Drinker respirator has received its name from the fact that it is the development of Professor Philip Drinker of that institution. Associated with him in the project was Prof. Louis A. Shaw. For their success in solving the problems involved in this device, and perfecting it so that it could be put to practical use in the conservation of human life, they were awarded a high honor in the form of the John Scott Medal, which was presented to them at the Franklin Institute of Philadelphia, in 1931.

The Drinker respirator has gained its greatest fame for its use in connection with poliomyelitis (infantile paralysis). Although the effects of this disease are most often confined to the limbs, and especially the lower part of the body, it occasionally affects the upper part, including the muscles involved in breathing. In these cases, the function of the respirator is merely to do the mechanical job of moving the patient's chest up and down, and keeping the lungs ventilated, until such time as the effects of the paralysis pass off.

It is interesting, however, that although medical applications of the respirator were foreseen, its initial conception and development came as the result of a determination on the part of the New York Consolidated Gas Company, now the Consolidated Edison Company, to improve available means of artificial respiration, particularly for victims of gas poisoning and electric shock. Through the company's Committee on Resuscitation and Related Activities, funds were made available, and an authority on the subject was sought.

The problem in its essentials was an engineering one, and for its solution Professor Drinker was well fitted. He was graduated from Princeton University in 1915, and had two years of post-graduate work in engineering at Lehigh University. His work at the Harvard School of Public Health, with which he has been associated since 1919, has included many industrial problems involving ventilation engineering and air conditioning. The matter was finally placed in his hands, and research and experimentation began in 1927.

Basically, the problem of artificial respiration consists, for adults, of moving into and out of the lungs, in a steady rhythm of about 15 times per minute, about 500 cc. or one pint of air. For children, the rate is more rapid, and the amount of air is smaller.

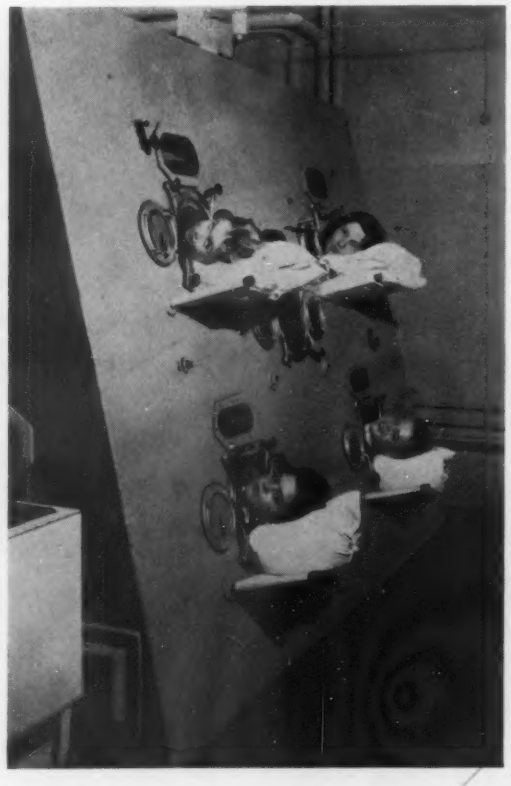
Most previous approaches to the solution of this problem have been from entirely different angles than that of the Drinker respirator. In the field of manual methods, the Schaefer method has been found to be much more effective in moving air into and out of the lungs than the older Sylvester method. It did, and still does, meet the requirements in emergencies where no other method is available, and it is by no means to be neglected. However, it reverses the normal process of breathing in that it depends on compressing periodically the chest beyond its normal resting state, while normal breathing consists of expanding it periodically beyond the resting state.

The biggest disadvantage of the Schaefer "prone pressure" method is that it is exhausting both to the person being resuscitated and to the person performing it. From a practical standpoint, the time limit for its successful use may be measured in minutes, or in exceptional cases, a few hours. Fortunately, this is sufficient in a great many emergencies, and if a longer period of artificial respiration is needed, it provides a little time for obtaining the help of such a device as the Drinker respirator, if one is available.

Previously the other main attack of the problem of artificial respiration has been along the line of inflating the lungs by means of an increased pressure of air or oxygen, applied through the medium of the breathing passages. The most celebrated of the devices working on this principle was the pulmotor. However, when this and other similar devices were investigated by a special commission consisting of Dr. W. B. Cannon, Dr. S. J. Meltzer, Dr. Joseph Erlanger, Dr. G. W. Crile, and Dr. Yandell Henderson, the principle was disapproved, largely because of the uncertainty as to whether the lungs or the stomach would be inflated, and because of the possibility of damage to lung tissues by excessive pressures.

The analysis of the problem indi-

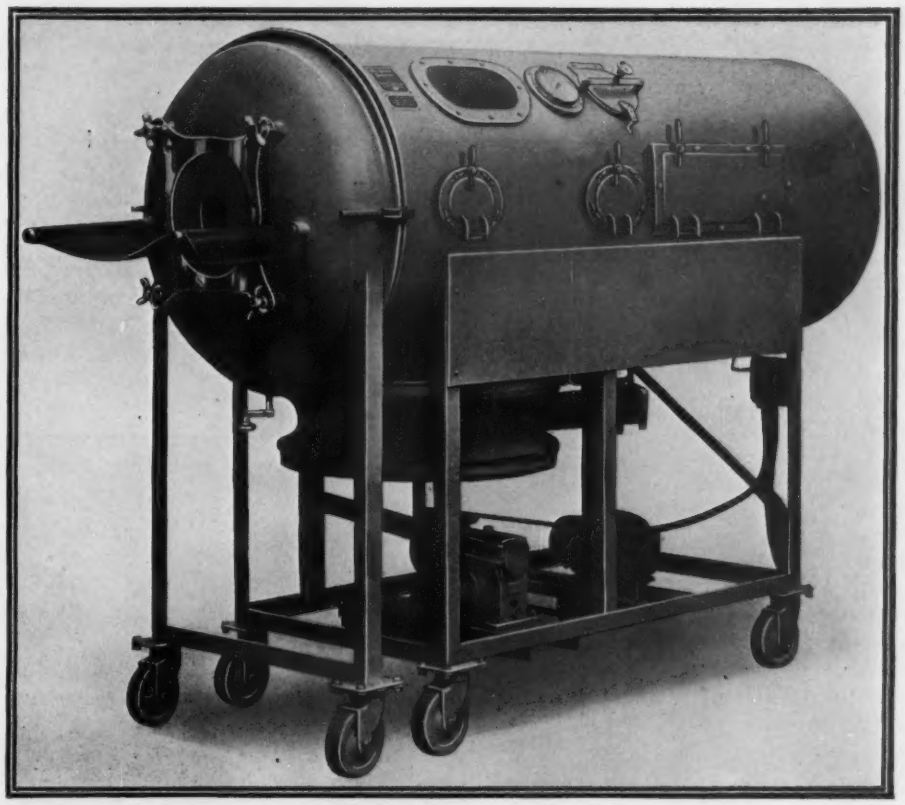
—Illustrations Courtesy Collins Respirator Co.



[Respiration room at Children's Hospital, Boston.

dicated the desirability of duplicating normal breathing as closely as possible. Since, as before pointed out, this consists in rhythmic expansion of the chest, Prof. Drinker set out to accomplish this as nearly as possible. He found that if a person's body were enclosed in an air-tight box, with the head protruding, and with the gap between the neck and the box closed by a soft rubber "collar," only a surprisingly small reduction of the interior pressure below that of the atmosphere was needed to bring into the lungs the same amount of air as in normal breathing. It was also found that these changes of pressure, while they caused breathing, did not affect the rest of the body.

The idea was tried out first, of course, on animals whose breathing had been paralyzed by the injection of curare. It proved entirely successful, but still when the time came to try it out on a human being, no one could be enticed into the crude, almost coffin-like box which was the first "Drinker Respirator," and Professor Drinker had to be the first subject. The required suction and pressure (a slight pressure was used at first but later found unnecessary) were provided by two ordinary vacuum cleaner fans.



The Iron Lung

In this connection, an equivalent of the first respirator could easily be constructed in emergency by anyone with some degree of ingenuity and a minimum of facilities. It would lack many of the refinements which actually become necessities if a patient requires treatment for any length of time, but it would still be an improvement over manual artificial respiration. Such a "wooden lung" was actually rushed from Toronto to Denver last summer by airplane, for use until a regular "iron lung" could be brought by rail from Chicago.

A workable respirator, using a cylindrical metal tank, was developed during 1928, and received its first use in the treatment of respiratory paralysis late that year and early in 1929. After considerable experimentation, it was improved mechanically to the point where it was a practical and convenient machine, and a technique of using it was developed. The chief mechanical problems to solve were providing means whereby the person to be treated could be easily placed in the respirator, and means for effecting a comfortable, yet air-tight, seal at the point where the neck protruded. The former was achieved by building the respirator as a horizontal metal "tank," with a removable closure at one end, connected to a cot inside in such a way that the head end and cot combination could be rolled practically all the way out of the chamber.

The neck "collar" was more of a problem, since it was necessary to provide for necks of varying sizes, from a small child's up to an adult's. It was finally solved by providing a ring by which the flat rubber collar was clamped against the head of the respirator. Four equally-spaced clamps provided adjustment of the pressure exerted by the ring, and by loosening one of them at a time, the collar could be stretched radially at that point and the clamp again tightened. By repeating this at each of the four clamps, the hole in the collar could be enlarged to any desired size and shape; though for widely different sizes of necks, different collars were provided in the beginning.

Among other early mechanical developments were the provision of "operating ports," which, after the opening of a hinged cover, allowed the insertion of arms through rubber diaphragms similar to the neck collar. These enabled attention to the patient, inside the respirator, without interrupting his breathing. A larger port on the side enabled the introduction of a bedpan.

The technique of using the respirator was fortunately found to be quite simple. One important point was the proper adjustment of the collar about the neck, and since the maximum pressure difference between the atmosphere and the inside of the chamber was relatively small, very little pressure on the neck was needed. Further, it was found that if the patient were placed well up in the respirator, the collar would bear chiefly against the bony parts at the base of the neck. This eliminated any sense of constriction about the neck, though oddly the impression still persists in the lay press that this is a major problem with the respirator.

For instance, *Time* magazine (June 14, 1937) in telling about Fred Snite, Jr., says that ". . . it was a long time before he learned to ignore the sensation of being throttled 21,600 times a day." That this is merely a "projected opinion" can be testified by any person who has been in a respirator, since practically the only sensation involved is that of having to breathe with the machine. It is only with considerable effort that one can resist the effect of the respirator. A most amusing demonstration is to have a person, when first placed in a respirator, count out loud. It is most uncanny, particularly to the person in the respirator, to have the sound of the voice vanish when the machine says "breathe in," even though the effort of speaking persists.

The remaining important points of technique were the proper regulation of the rate and the amount of the pressure changes in the chamber. Through many years of experience, it has been found that the rate is not at all critical as long as it is within certain limits. A choice of several speeds, in the range of from about 14 to 35 respirations a minute, provides for everyone, from adults to small children. As before mentioned, it was found that only rhythmic gentle negative pres-

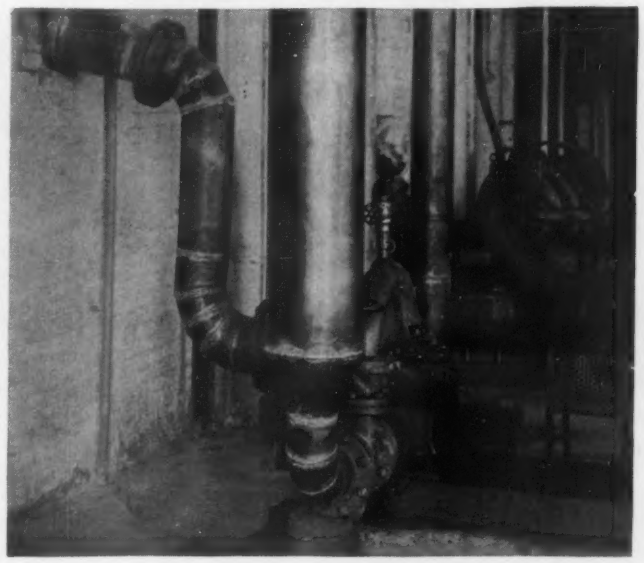
(Continued on page 194)

Welding of Alloy Steels

Different Compositions Require a Variety of Techniques

MILTON MALE

DEMANDS for better performance at lower ultimate cost have always stimulated engineers to provide for new wants by new products. The wide scope of progress has consequently imposed a whole set of new and more exacting requirements on one of our indispensable engineering materials—steel. The particular properties most often desired are higher yield and tensile strengths concurrent with the same or enhanced ductility, improved corrosion and abrasion resistance, better fatigue and impact strengths. As a modern fabricating process, welding has extended into innumerable fields where these properties are wanted for structures of every description. Were it not for cost and weldability, heat-treated carbon steels might be found suitable; actually, it is becoming increasingly expedient to use alloy steels. Whether or not a given alloy steel is acceptable for a specific purpose may depend, to a considerable extent, on its weldability.



—*Illustrations Courtesy Oxy-acetylene Tips.*

Bronze-welded reducers.

What determines whether a steel is weldable? Although one might not find it in print, engineers and metallurgists have established for their own use a criterion of weldability which will suffice for the broad purposes of this article. We shall consider weldability to be the capacity to assemble a structure by welds which have most of the desirable properties of the base metal. It is not sufficient to consider, as some have done, maximum hardness alone; for, while certain steels like medium or high carbon grades are hard and brittle, others such as nickel-molybdenum grades are hard also, and yet tough. Furthermore, it should be kept in mind that what may constitute an acceptable combination of hardness and ductility in the weld, or in the adjacent heat-affected zone of the base metal, depends on the application for which the steel is intended.

It is generally recognized that plain steels with carbon up to about 0.30 percent can be welded satisfactorily under usual commercial practice. In the case of higher carbon steels and alloy steels, weldability is dependent upon such factors as metallurgical characteristics, including chemical composition and heat treatment before or after welding, and the welding process and technique employed. Before discussing the welding of specific alloy steels, let us first consider some of the common factors.

Except in certain special cases, any of the usual welding processes may generally be employed with equally satisfactory results. The fusion welding processes—electric arc (direct current, alternating current, and carbon arc) or oxyacetylene—are both extensively used in commercial work. In arc-welding alloy steels, heavily covered steel wire electrodes are used almost exclusively because of the superior properties of the resultant weld metal. In many cases the desired alloying elements are introduced into the coating of the wire rather than in the wire itself.

The oxy-acetylene process is particularly adapted to the welding of thin material. It may also be preferred for the welding of certain alloys where the slower heating and cooling of the metal, as compared to that of arc-welding, has definite advantages.

Electric resistance welding (spot-welding is the most common form) is usually the most economical process to use where the steel is thin (not over about $\frac{1}{8}$ inch thick), and where the welding can be done in the shop in quantity.

If equally good welds can be made in alloy steels by two or more of the welding processes, the availability of equipment and the cost of the finished product are the considerations that generally govern the choice.

A homely illustration from the field of aeronautics may be borrowed to clarify one of the metallurgical characteristics, which are so important in welding operations. In an airplane flight, it makes relatively little difference whether the ascent be gradual or rapid, provided undue distortion is avoided. However, if after reaching an altitude of 3,000 feet, it were necessary to "bail out" in a parachute, the rate of descent becomes a matter of vital importance. Other things being equal, the chances for a safe landing are better if the descent is slow, and, for a given rate the chances of landing without being smashed to bits are improved if one can drop on a soft haystack rather than on hard concrete.

This situation may be aptly applied to welding, since weld metal is always melted and then solidified, and the adjacent base metal is unavoidably heated and cooled. From a metallurgical standpoint, the rate of heating makes but little difference except that, if it is too rapid, undesirable distortion (or even breakage) of the structure may result. But the rate of cooling from welding temperatures exerts a tremendous influence on the ultimate properties of the work, since, in general, the faster the rate the harder is the steel; and for a given rate the chances for a sound weld free from cracks are improved if the base metal is soft.

Certain alloying elements, notably manganese, chromium, and silicon, markedly affect the degree of hardening upon cooling from welding temperatures, under any specific conditions. Since rapid cooling of any steel always produces finer distribution of carbides, and hence harder characteristics, it follows that the presence of such alloying elements intensifies hardness. A good general rule to follow when considering weldability is that when these alloys are present the carbon content should be kept appropriately low.

The cooling rate also affects the magnitude and distribution

which are air-hardening are particularly affected and will usually require a stress-relieving treatment before being put into service.

The following information on the welding of specific alloy steels is believed to represent what is now generally accepted as good practice. Since the art is still in a state of rapid change —in that new alloys and techniques for welding them are being constantly developed—it is not feasible in such a brief discussion as this to do more than present information concerning those alloys with which, at the present time, the writer is most familiar.

It may be convenient for discussion to classify arbitrarily alloy steels into two broad groups—the low-alloy steels, with total alloy content generally less than 5 percent, and the high-alloy group, with total alloy content 5 percent or more. Carbon is not considered here as an alloying element.

The low-alloy steels can be discussed under the two heads of mechanical engineering steels and construction steels. The mechanical engineering group will be considered first.

Chrome-vanadium steel is used for pressure vessels, tubing for the chemical industry, and for many other applications where high physical properties are required at both room and elevated temperatures up to about 950° F. For good weldability, the carbon is generally restricted to about 0.20 percent maximum. Chemical composition and physical properties of a typical grade of this steel are given below:

Carbon	— 0.10–0.20 percent
Manganese	— 0.30–0.60 "
Silicon	— 0.20–0.30 "
Chromium	— 0.80–1.10 "
Vanadium	— 0.15–0.20 "
Yield Point, Lb./sq. in.	= 60–70,000
Tensile Strength, Lb./sq. in.	= 80–90,000
Elongation, percent in 2 inches	= 35–25
Reduction of Area, percent	= 55–50

High grade heavily coated electrodes, of chrome-vanadium, or chrome-molybdenum grades, are preferred for welding. Welds made with such electrodes will have yield and tensile strengths as high as the base metal, with somewhat lower ductility. If preheating is required on thick sections, a temperature of 300–500° F is good practice. The use of this alloy steel should be avoided if stress relief is necessary subsequent to welding, since the annealing temperature of 1100–1200° F may produce temper brittleness, with marked reduction in impact strength.

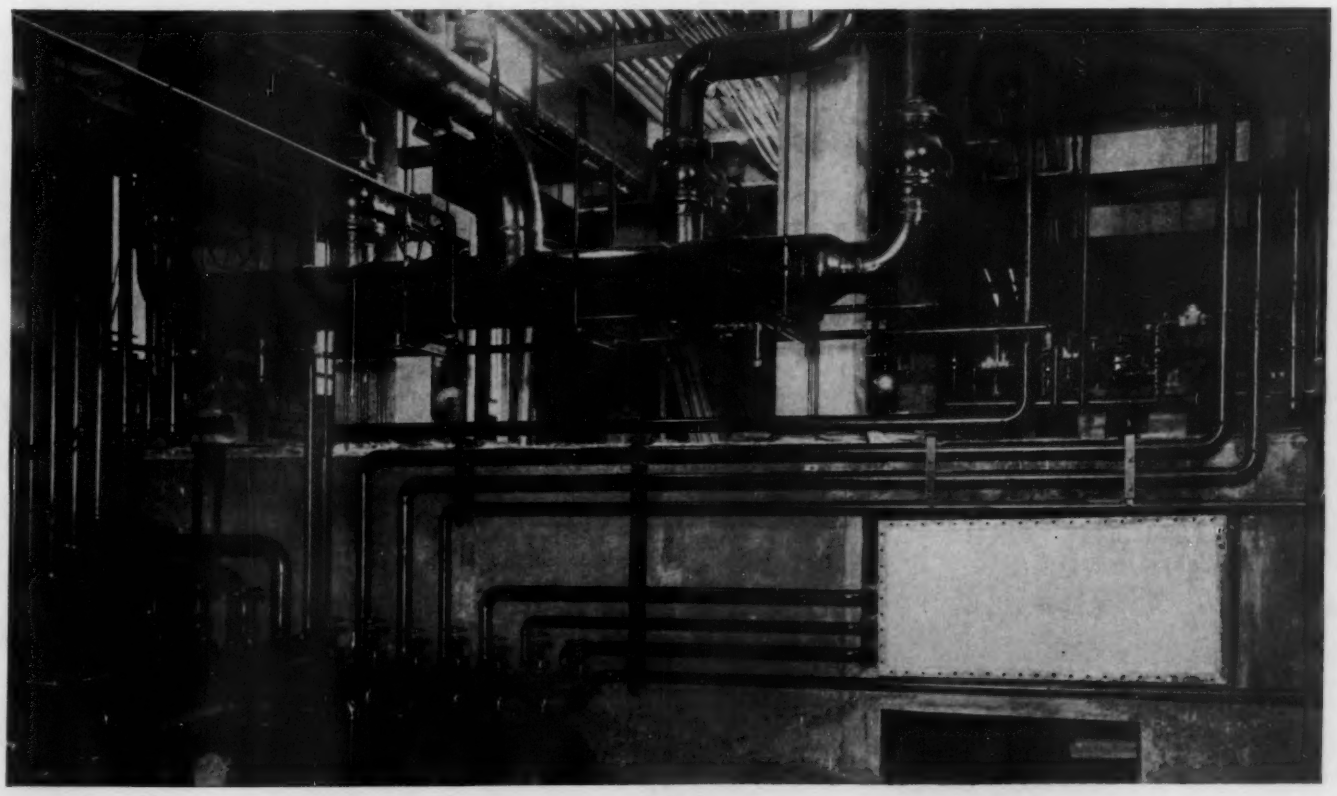
Manganese-vanadium steel is used where high strength, combined with toughness and good weldability are required for structures subject to bending and impact stresses. The carbon is kept low to avoid air hardening. The vanadium promotes a fine and uniform grain size and at the same time prevents segregation of carbides. The following is a typical analysis of a structural grade with physical properties as indicated:

Carbon	= 0.15–0.20 percent
Manganese	= 1.30–1.50 "
Vanadium	= 0.10 "
Silicon	= 0.20 maximum
Yield Point, Lb./sq. in.	= 55–65,000
Tensile Strength, Lb./sq. in.	= 88–95,000
Elongation, percent in 2 inches	= 20–10

Heavily coated electrodes or high test gas welding rods should be used to produce sound welds. Chrome-vanadium or chrome-molybdenum rods have been found most satisfactory. Preheating or subsequent annealing are not required for the structural grade described above, but may be found desirable if the manganese and vanadium contents are increased.

The addition of molybdenum to chromium steels results in marked improvement in mechanical properties. Such steels of residual or locked-up stresses in the finished weld. Steels

The bulk and weight of piping systems are reduced to a minimum by welding.



find application in steam service at elevated temperatures where high creep resistance is required. Chrome-molybdenum steels have also been extensively used in the manufacture of aircraft parts. A typical grade (S.A.E.X4130) is as follows:

Carbon	— 0.25–0.35	per cent
Chromium	— 0.80–1.00	"
Molybdenum	— 0.15–0.25	"
Manganese	— 0.40–0.60	"
Yield Point, Lb./sq. in.	= 60–70,000	
Tensile Strength, Lb./sq. in.	= 100–110,000	
Elongation, percent in 2 inches	= 30–20	

Heavily-coated carbon-molybdenum electrodes, or a high tensile chromium-molybdenum gas-welding rod should be used to develop the full strength of the base metal. Preheating before welding, followed by subsequent heat treatment after welding, should be employed, particularly when using the gas welding process.

For applications where a low cost alloy steel is desired to resist abrasion (such as in coal chutes, mine screens, concrete buckets, conveyors), a grade of steel known as AR, or Abrasion Resisting Steel, is available, containing Carbon 0.35–0.50 percent, Manganese 1.50–2.00 per cent and Silicon 0.15–0.30 percent. In the as-rolled condition, its tensile strength is approximately 100,000 to 125,000 lbs. per sq. in. with a Brinell hardness of about 200 to 250. It can also be heat-treated to develop a tensile strength of at least 150,000 lb. per sq. in. This alloy has distinct air-hardening characteristics. For satisfactory welding, the steel should be preheated to at least 650° F, and a high grade, shielded arc electrode used. Whenever possible, stress relieving after welding is desirable to reduce air hardening in the zone adjacent to the weld.

The use of low-alloy construction steels is not new, structural silicon and nickel steels having been extensively used in the past for bridges when higher strengths were specified than could be furnished in ordinary structural steels. More recently, for use in railroad rolling stock, machinery, and other diversified fields, a special group of steels has been developed which combine high strength and good ductility, and which can be fabricated by welding. Certain grades of steel also have higher corrosion resistance than ordinary steels, a factor which is important when using thin sections.

Nickel increases the strength, yield point, and hardness of steel with a remarkably small loss of ductility. These characteristics are utilized in structural shapes, eyebars, and boiler plate which, due to size or shape, are impractical to heat-treat beyond normalizing or annealing. While several grades of 3½ per cent nickel steel are available for structural work, the lower carbon grades are preferred for welding. A typical analysis (S.A.E. 2315) is as follows:

Carbon	— 0.10–0.20	percent
Nickel	— 3.25–3.75	"
Silicon	— 0.15–0.30	"
Manganese	— 0.30–0.60	"
Yield Point, Lb./sq. in.	= 55–60,000	
Tensile Strength, Lb./sq. in.	= 80–90,000	
Elongation, percent in 2 inches	= 25–20	
Reduction of Area — percent	= 55–50	

Air-hardening tendencies of these steels may be reduced by a slight preheating. Gas welding, which furnishes the necessary preheating as an inherent accompaniment of the process, will generally produce satisfactory welds practically free from brittle zones. In the arc welding processes, various electrodes are in common use, such as low carbon, 3½ percent nickel, and molybdenum alloy electrodes; and by the use of the proper technique, properties approaching those of the base metal can be produced in welded joints. A stress-relief anneal at 1200° F will be found helpful in reducing hardness.

Cromansil steel contains chromium, manganese, and silicon as its principal alloying elements. Weldable grades of this alloy usually restrict carbon content to a maximum of 0.20 percent. The high physical properties and good weldability of this grade of steel are reflected in the wide use of Cromansil for such applications as engine and truck frames for railroad cars, and parts for heavy machinery. The chemical composition and physical properties are as follows:

Carbon	— 0.10–0.25	percent
Chromium	— 0.40–0.60	"
Manganese	— 1.10–1.40	"
Silicon	— 0.70–0.90	"
Yield Point, Lb./sq. in.	= 50–65,000	
Tensile Strength, Lb./sq. in.	= 80–95,000	
Elongation, percent in 2 inches	= 30–20	
Izod Impact, Ft. Lbs.	= 25–40	

Good welds are obtained in sections up to about ¼ inch thick with high strength shielded arc electrodes or with the oxy-acetylene process using high test rods. For thicker sections manganese-molybdenum rods and electrodes are preferred, since the diffusion of the alloying elements from the base metal into the weld is not sufficient to raise the strength of ordinary filler metal to the required values.

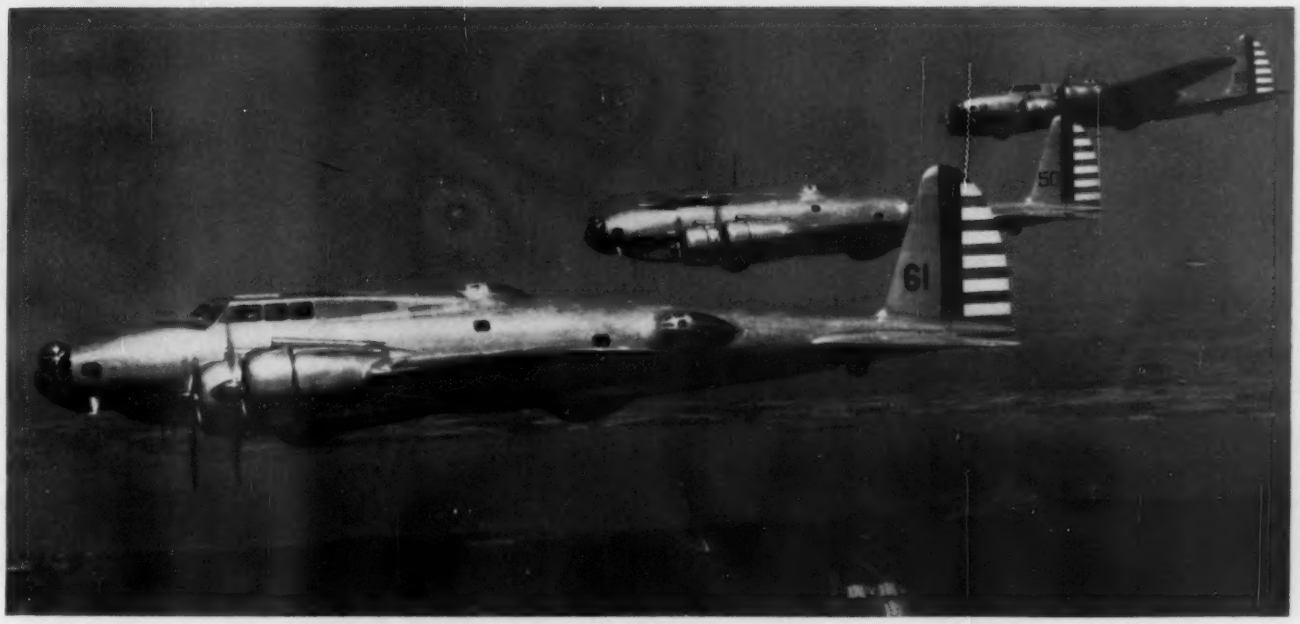
Typical test results obtained in welds on 0.20 percent carbon Cromansil steel are given below, the higher values being realized with alloy steel electrodes:

Yield Point, Lb./sq. in.	= 56–63,000
Tensile Strength, Lb./sq. in.	= 86–98,000
Bend Elongation, percent	= 35–20

Oxy-acetylene welds are readily made in both the 0.10 and 0.20 percent carbon grades in plates up to about ⅜ inch thick, with strengths comparable to that of the base metal. With

(*Continued on page 198*)

A cast iron steam chest repaired by welding.



—Courtesy Military Engineer.

The Flying Fortress

ERLING H. HUSTVEDT

IN August, 1935 appeared a plane that impressed the world. It was the tremendous Boeing bomber, 229, more popularly known now as the "Flying Fortress." Sceptics soon began to doubt the practicability of such a large plane when it met with mishap on its test flights. On the first flight the ailerons were left locked; on the second flight the air brakes were on when the plane landed, with the result both times of extensive damage. Despite the jinx which seemed to be accompanying the ship,its development was continued, so that on its third flight the plane, renamed YB 17, was flown successfully.

The plane has a single mid-wing with a span of one hundred feet. Its length is seventy feet, and it is fifteen feet high. Four 750-horsepower, Pratt and Whitney engines drive its seventeen tons total mass through the air at a speed of two hundred and fifty miles an hour. The tail wheel and the two large landing wheels are retractable. The equipment of the plane is quite complete. It has a radio-telephone for communication, a radio direction finder for determining a course, and an automatic pilot for keeping the course. This plane is the first to use landing wheel air brakes, which since the second flight have proved satisfactory. An auxiliary generator provides one hundred and ten volts alternating current for lighting and for the operation of equipment. The entire interior of the plane is heated, thereby eliminating bulky flying suits, and so increasing the comfort and the efficiency of the men.

Unlike former bombers the YB 17 needs no accompanying planes for protection. Five glass inclosed machine-gun turrets scattered over the plane's surface, one in the nose, one on top, one below, and one on each side, afford ample protection from all angles of attack. Its great speed is also a factor of protection.

One might well expect such a tremendous plane to be unwieldy to handle and ponderously awkward in appearance. The opposite, however, is true. The plane is easier to control than most small ships, and its clean lines with its long, shiny fuselage and its tapering wings make it one of the most graceful of airplanes.

The great advantages of the plane more than compensate for the added expense in its construction, maintenance, and personnel. Per ton of bombs it is actually cheaper than smaller planes. The plane's great speed and range were proved by an early test flight, in which a group of the planes flew from March Field, California to Langley Field, Virginia, a distance of 2450 miles, in twelve hours and fifty minutes with but a normal fuel load. One of the principal advantages of the plane is the interchangeability of its bomb and fuel loads. On short flights an extra heavy blow can be given by the bombers on hand, or the required blow can be delivered by fewer bombers. By replacing their bombs with extra fuel tanks, the YB 17's become reconnaissance and long range bombing planes of remarkable ability.

One of the few drawbacks to the plane is its need for large landing fields; its long range, however, keeps this from being too great a difficulty.

The thirteen YB 17's now in Army service have proved so successful that a still larger plane of the same type, the YB 15, has been developed. This new plane, which was successfully tested a few weeks ago, has a span of one hundred and fifty feet, is ninety feet long, and eighteen feet high. It weighs thirty tons. Although it is powered by four one-thousand horsepower engines, its speed is somewhat less than the YB 17. Double landing wheels replace the single ones, and in addition there is a retractable nose wheel.

It will be interesting to see what the future development of the bombing plane will be, to see whether still larger planes will be built, whether there will be a development of fast attack planes which will make large bombers less practical, or whether ships like the YB 17 will continue to be called impregnable "Flying Fortresses."

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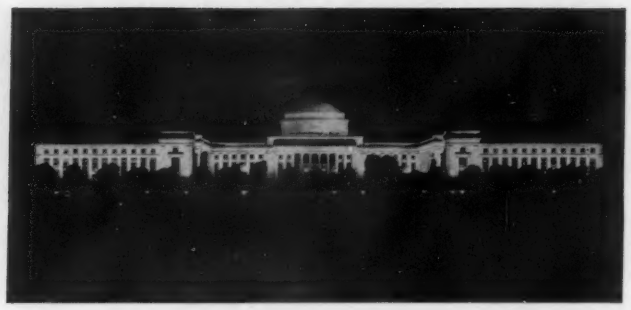


EDITORIALS

SEX EDUCATION

THE average college student is enough of an egoist to believe that he knows just about all he should about sex. He is usually quite wrong, however, and as a consequence he plunges headlong into marriage without the slightest knowledge of the responsibilities that face him. This applies to the average woman as well as the man, but we are interested here at Technology in the male side of the question. Because of this prevailing ignorance, many marriages are breaking up in the divorce courts, and many are just barely struggling along making the best of what might be called a bad bargain. Numerous marriages fail primarily because both parties are either entirely ignorant of the marriage relations, or because what little they do know has been picked up in dormitory or fraternity "bull sessions." Such information is usually incomplete and often extremely harmful in later days. Of course, some parents do give advice to their children, and this is very sensible and helpful, but a good number of people are still too prudish to mention sex except in low whispers and with smirking side glances. Prudishness has contributed as much to unsuccessful marriages as any other factor.

Another thing that is instrumental in the misconceptions of marriage is the common attitude of so many males that a woman is merely something with which he may satisfy his biological needs. It never enters into the consciousness of some men that a woman may have a mind as good as his own and sometimes better. The recent poll of THE TECH bore this out in some respects, for most fellows were not too critical of their girl friends, although they were still conservative or perhaps conventional enough to revert back to the ideal of the old-fashioned girl for their wives. Such an attitude is deplorable, for it immediately suggests the idea that women are inferior. Perhaps the results of the poll do not represent the true principles of the average Tech man, but the great preponderance of those who voted as they did seems to belie this.

The swift rise of women into the competitive world has tended to show that women insist upon being held the equal of men in all things, and gradually, though sometimes grudgingly, they are being accorded equality. If women are becoming recognized in the professions of the world, why shouldn't they be equal in marriage, which still remains their greatest career? Of course, it may be argued that women are absolutely free in the home, but that is not the point. Most men are inconsiderate of their wives in marriage relations. They do not seem to appreciate that women possess a different sort of tem-

perament. This difference must be considered and instilled into both men and women. If, then, two persons are sexually incompatible not through physical defects, but because of ignorance, society is to blame for not having provided the proper education.

High school may be considered by some to be the proper place for sex education. To a certain degree, yes; but the average high school student has not enough mental maturity to assimilate properly such an education. It should be the function of the college and university, therefore, to provide their students not only with the knowledge of how to make a success in the business world, but also how to make a success in marriage. Technology, which has shown itself repeatedly in the forefront of progressiveness, should not hesitate to train its students to be good husbands as well as fine engineers.

AN ANNIVERSARY

SEVENTEEN years ago the great industry of radio broadcasting had its inception in the modest form of station KDKA. Recently the whole industry celebrated this anniversary with the dedication of a huge, new, 718-foot steel mast to be used by KDKA—a far cry from the unpretentious equipment of the old days.

The beginning of broadcasting, which was simultaneous with the beginning of KDKA, is extremely interesting, for it shows how broadcasting suddenly mushroomed into the tremendous thing that we merely take for granted today. The original idea was an outgrowth of the work of amateurs, as so many advances in radio have been. It began thus. Dr. Frank Conrad had tinkered with radio equipment since 1912, and had communicated with numerous "hams." His first broadcasting, however, was with phonograph records borrowed from a neighborhood dealer. These broadcasts rapidly became popular, and soon sets were sold for the express purpose of picking up his programs. It wasn't long before the Westinghouse Company took up Conrad's idea, and the result was KDKA. From phonograph records to small musical organizations, and thence to a symphony orchestra were rapid steps. The wider scope of activities necessitated expansion—first into a large auditorium, and next, because of room resonance, into a large tent. Blown away by a high wind, the tent was not practical outside, but inspired the thought of having it erected in a room. The success of this move lead to the plan of draping the walls with burlap, and finally, as today, to the specially constructed studios of modern broadcast stations.

From purely musical programs the station advanced to broadcasting church services, appeals and addresses, time signals, sporting events, and even agricultural reports and weather forecasts. As the field widened, technical advances of all sorts became necessary, and training was requisite for both announcers and technicians. Meanwhile, KDKA had not been alone in this baby industry, and hundreds of stations came on the air because of popular demand, forcing the amateurs down to the short waves. Here again the amateurs showed their capabilities, as they pioneered and explored the vast regions of the then despised short waves. Their activity showed the utility and immense value of this strata, and consistent long distance communication, day and night, became practical.

Today, after seventeen years of success, the radio industry has become not only a dispenser of amusement, but also a vital factor for influencing the thoughts of the people. The honeyed voice of our president, the strident tones of dissidents, as well as the glories of symphonies and operas can all be heard at one's convenience merely by the twist of a dial. Radio can, in the hands of a dictator, become an instrument of intense danger, however, and this may become even worse when television is perfected; for here would be the opportunity to transmit both the voice and features of a person to untold millions.

Despite some abuses, and some indiscriminate advertising, the radio industry has much to be proud of, for in America where it is operated for the benefit of the people, radio is almost a necessity in our lives—for communication, amusement, and education. Spectacular as its advance has been, there are, doubtless, still untold fields of endeavor for experimenters, both technically and administrative.

SALESMAN OF DEATH

NOT long ago a man died whose effect while alive was felt throughout the world. Though he is dead, his kind still fleets surreptitiously from capital to capital planting the seeds of war and death. The man—Sir Basil Zaharoff, so-called "mystery man of Europe;" the type—the munitions salesman. These men are truly men without a country, for they will not hesitate to sell munitions to countries which may at any time become embroiled with the country which is ostensibly their own.

Secrecy, sham, and hypocrisy are the tools of the trade, facts that are borne out by Italy's construction of a light cruiser for Soviet Russia, against whom the vehement tirades of Mussolini are broadcast. Nor is Italy the only country to engage in such double-dealing. England, arming furiously against the threat of a possible German expansion, sells Rolls Royce engines to power German airplanes; and prior to the Ethiopian conquest, England sold more arms to Italy than did any other country, despite her fervent condemnation of Italy in the League of Nations. Even the United States is not free from munition machinations, as the Nye committee so forcefully showed.

(*Continued on page 193*)

—*Courtesy Scientific American.*

RESEARCH IN REVIEW

COURSE VI — Ultra-High Frequencies

THE widening field of usefulness for ultra-high frequencies in radio communication has stimulated research leading to the development of equipment for making measurements at those frequencies. The obstacle to the perfection of a satisfactory device, however, has always been the lack of a suitable power source. It is true that vacuum-tube oscillators employing improved vacuum tubes have permitted the use of circuits which govern the frequency of oscillation to a much greater degree than in the older tubes. Several tank circuits for frequency stabilization have been developed, notably the parallel-wire and coaxial transmission lines, and the Kolster toroid, but none of these has satisfied the four requirements which must be met. These are as follows: (1) A high degree of frequency stability under varying external conditions; (2) a confined electromagnetic field; (3) ample output as a source for high frequency measurements; (4) a convenient physical size.

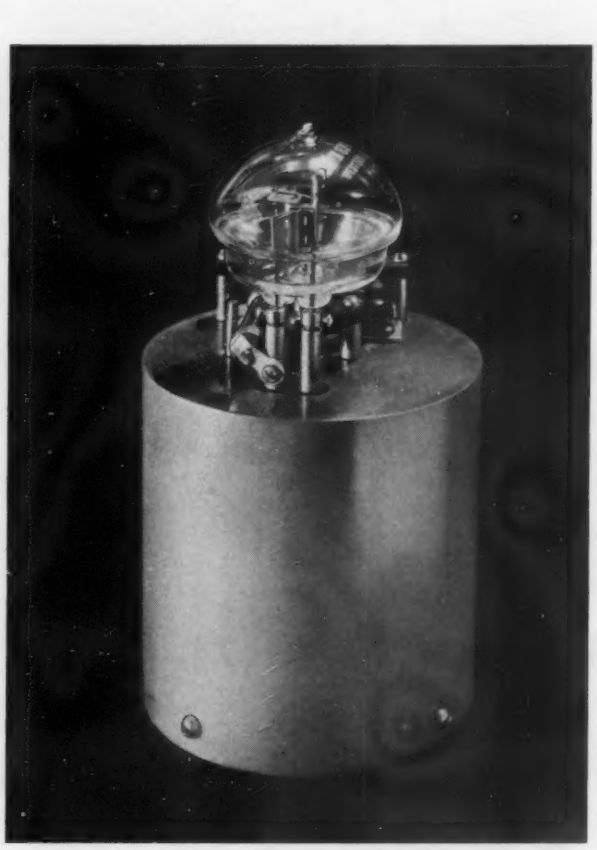
Working in the laboratories of the Department of Electrical Engineering, Mr. Arnold Peterson, graduate student and member of the staff, has finally effected a good compromise between the conflicting prerequisites. He has developed a new oscillator, utilizing a vacuum tube especially designed for the ultra-high frequencies, coupled to a lumped concentric element tank-circuit. The tank circuit consists of an outer containing-cylinder with a cylindrical piston-shaped insert. It is perhaps simplest to consider the oscillatory tank circuit as an L-C circuit, whose capacitance is that formed by the outer cylinder and the large inner copper tube, and whose inductance is that of the field surrounding the inner tube. The dimensions of the tuned circuit are sufficiently small in comparison with the wave length to permit its treatment as a lumped circuit.

The effectiveness of this oscillatory circuit for frequency stabilization is the result of the low losses in its component elements. Of equal importance is its connection to the vacuum tube in such a manner as to appear as a circuit with elements of low reactance. The tank capacity of the oscillator illustrated is about 130 mmf., and its tank inductance is about 18 cm. At its operating frequency of 100 megacycles, the Q of the resonant circuit is approximately 2500.

Some properties of the new oscillator which are of special interest deal with the effect of variations in electrode voltages upon the frequency of oscillation, the effect of loading, and the drift in frequency during the warming-up period. Because of the method used in the measurement of changes in frequency, the results of the experimenter show no appreciable drift effect, and can be considered as essentially dynamic measurements. That is, the effect of physical changes in the oscillator as a result of varying thermal conditions was minimized in order not to mask the effect of dynamic changes in the tube parameters.

A rapid variation of the applied filament voltage produced only a very small shift in frequency. However, a slow variation in voltage, which permitted the thermal equilibrium to reestablish itself produced a change in frequency opposite in sense to, and somewhat greater in magnitude than that produced by the rapid variation. The ambient temperature coefficient of frequency in the oscillator has been made less than the temperature coefficient of expansion of the metals utilized in the tank circuit. This reduction has been accomplished by properly employing the differing coefficients of brass and copper to produce a tank capacitance with a negative temperature coefficient which approximately balances the positive coefficient of the inductance. By this means, an ambient temperature coefficient of frequency of less than 5 parts per million per degree Centigrade is readily achieved.

The drift in frequency of oscillation during the warming-up period was later calculated and graphed under different conditions. This drift, approximately proportional to the input power to the plate circuit, is primarily the result of changes in the spacing of the tank condenser. The varying thermal conditions responsible for these changes can be traced to the temperature differential developed in the oscillator. By alteration in the design of the given tank circuit, the factors producing the drift in frequency will be materially reduced. However, in order to accomplish this reduction, the physical size should be increased, or the resultant frequency stability during varying electrode voltage conditions will be lessened. For a given application of this type of oscillator, unless compensation is provided, a design which effects the best compromise should, of course, be adopted.



—Courtesy General Radio Experimenter.

The complete osillator, consisting of tank, circuit, and vacuum tube, has an overall height of only 7 inches.

COURSE V — Synthetic Alcohols

SUCCESSFUL methods for obtaining alcohols from unsaturated hydrocarbons (particularly those hydrocarbons which are a by-product in the cracking processes in the manufacture of gasoline) have been employed on a large scale for a

number of years. For example, prestone synthesized from ethylene has found wide use both as an anti-freeze compound, and as the basis for the manufacture of explosives similar to nitroglycerine. While the methods employed have been good, the search for improvements has been kept up.

The November issue of the JOURNAL OF THE AMERICAN CHEMICAL SOCIETY contains an account of experiments carried out recently by Nicholas A. Milas and Sidney Sussman in the Department of Chemistry which set forth a catalytic method for forming alcohols from unsaturated (or olefinic) hydrocarbons. The success of this catalytic process in the laboratory is of considerable scientific interest, and it may lead to important improvements in commercial practice.

Stated briefly, the process involves first mixing a solution of hydrogen peroxide with anhydrous tertiary butyl alcohol, to which has been added vanadium pentoxide, chromium trioxide, or osmium tetroxide as a catalyst. The resulting mixture is then treated with an unsaturated hydrocarbon (olefin). Under the conditions maintained, hydrogen peroxide behaves as if it were formed by linking two hydroxyl groups (OH-OH), having the property of breaking apart under the influence of catalysts of the types mentioned, and then adding across what is termed the carbon-carbon double bonds, characteristic of olefinic unsaturated hydrocarbons. There is some evidence to suggest that the actual mechanism of the reaction depends upon an intermediate formation of the unstable peracids of the catalysts used. That is to say, pervanadic or perchromic acid may be formed first, which in turn transmits hydroxyl groups to the hydrocarbon.

Gaseous hydrocarbons, such as ethylene, were bubbled through the hydrogen peroxide solution, but the reaction was not completed by a single passage of the gas. It was found that an apparatus permitting a recirculation of the used gas gave practically quantitative yields of the alcohols. For example, from ethylene the production of ethylene glycol reached as high as 97 percent.

It should be noted that while this method yields dihydroxyl alcohols (called glycols) in most cases which have been tried, the possibility of wide usefulness exists. Thus the two well-known hydrocarbons, *diallyl* and *d-limonene*, each gave tetrahydroxy alcohols, in yields of 45 and 35 percent respectively.

One very important monohydroxy compound, namely, phenol or carbolic acid (which is not an alcohol) was obtained in a yield of 23 percent. This result is notable because it permits the formation of phenol directly from benzene. In this case, the mechanism of the reaction is thought to involve the initial formation of the glycol, 1, 2-dihydroxycyclohexadiene-3, 5, which then is dehydrated to give phenol. The usual process, now employed on an industrial scale, requires the preparation and isolation of an intermediate product.

Up to the present time, about fourteen compounds having alcoholic hydroxyl groups and three having phenolic hydroxyl groups have been obtained by this method.

Radioactivity

THE major work of the Research Laboratory of Inorganic Chemistry is being directed at present toward the study of certain phases of natural and artificial radio activity. In co-operation with Professor R. D. Evans and his associates of the Department of Physics, several special problems of physical and chemical interest have been brought under consideration.

The age of a meteorite definitely believed to have reached the earth from outside the solar system will be determined by a combination of careful analyses. The infinitesimal content of protoactinium present must first be separated, so that physical measurement of its radioactive properties can be made. By a known mathematical relation between the amount of radioactive substance at any time and the rate of decomposition, the "life" of the meteorite may be determined. The results thus obtained will furnish the first evidence yet secured as to the age of objects in extra-solar space.

The subject of the trans-uranic elements—elements of atomic number greater than that of uranium (92), is also being investigated in this Laboratory, with the purpose of furnishing much-needed corroboration of the claims of European experimenters. It has been set forth that uranium, on bombardment with neutrons, is converted successively into element 93 (eka--rhenium), element 94 (eke-osmium), and elements of still higher atomic number.

A technique is being developed whereby it is expected that the vapor pressure of very slightly volatile compounds of radioactive elements may be measured by determining the amount of radioactivity acquired by a known volume of an inert gas which has been slowly passed over the substance.

In addition to these problems on radioactivity, the Laboratory is engaged in the further study of some of the rarer elements, such as rhenium and indium; the preparation and study of the properties of organo-silicon compounds, the hydrides and other compounds of boron, and the metal carbonyls and related compounds.

COURSE IX — New Courses

COURSE IX contains no staff and no equipment that it can call its own. There are no beakers to wash, no valves to grind—not even a "Danger-High Voltage" sign. Research in Course IX is essentially a study of courses of instruction. As a proving ground for new schedules, it has many times proven its worth. At least three of the major courses and four of the minor options at the Institute originated in Course IX.

In the evolution of a new course of study, the participating student is asked first to present a complete schedule for four years' work. This schedule is brought to the attention of various members of the faculty for criticism and comment. The choice of advisors is, of course, suggested by their recognized experience with the objective under consideration.

An effort is invariably made to obtain suggestions from leaders in the associated industry, for the outside viewpoint is considered of great value. Advice is freely given by executives and engineers in high places, and no one seems too busy to help plan courses.

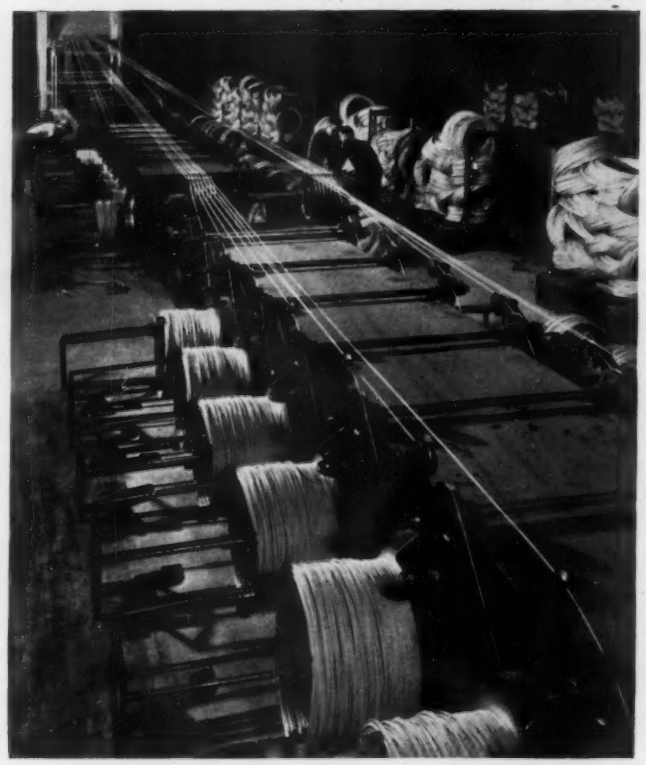
The next problem is the reconciliation of the various schedules that have been proposed to meet the stated purpose. The inside criticism is apt to be objective; the outside is predominantly subjective. The schedule finally comes back to the student for modification and acceptance, with the definite understanding that the adopted course must remain in focus with the main objective.

In this manner, courses have been evolved recently which relate to packaging engineering, preparation for patent law, refrigeration and air conditioning, illuminating engineering, optics and photography, and technical journalism. The spirit of inquiry engendered by the preliminary survey often leads to a recapitulation of the fundamental factors, as, for example, in a recent instructive thesis on "Patent Law and the Institute."

The administrators of Course IX have always been guided by a very simple principle. They have recognized that we will always have men of standard dimensions who can be well fitted with ready-made suits. Others there must always be who require a suit measured and cut to order. So it is with college courses. There would have been no change in college curicula since the beginning if some one had not stepped out of line and asked for a new schedule.

ENGINEERING DIGEST

STEEL WIRE MILL

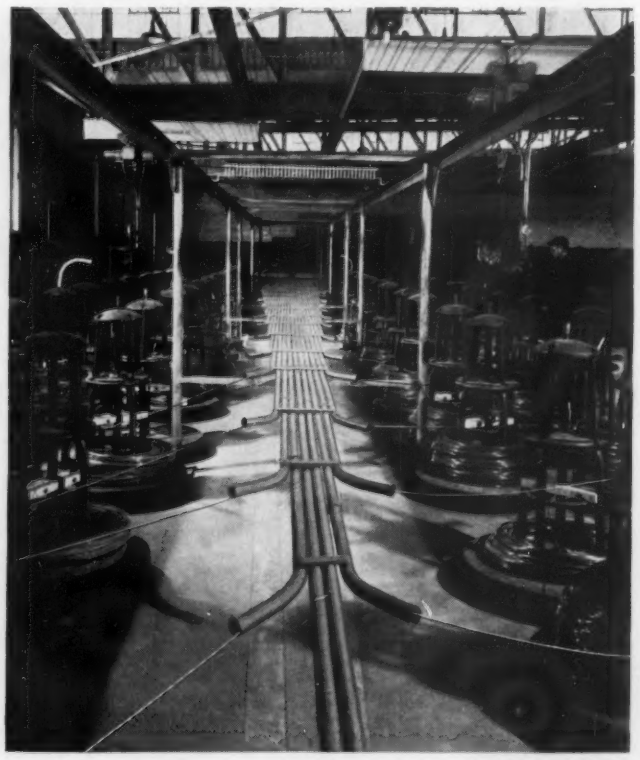


HIGH speed work-handling equipment, automatic electrical devices, and chemical apparatus of the latest design have been used to expedite continuous production at the new wire and steel mill of the Republic Steel Corporation at South Chicago, Illinois.

The wire is brought in from the storage yards and is thoroughly cleaned by passing through acid baths and gas-fired ovens. It is conveyed to the drawing department by specially equipped electric trucks. There, eleven machines draw the wire, some only once or twice and others as many as five or six times. Fine wire is drawn at the rate of from 290 to 860 feet per minute and larger thicknesses are drawn at a speed of from 1,000 to 14,000 feet per minute. Water cooled tungsten carbide dies are used on all drawing machines. Continuous drawing is made possible by welding successive coils end to end. An example of the efficiency which this equipment makes possible is shown by the fact that as many as 578 miles of fence wire, electro-galvanized with 17 layers of zinc, is produced daily.

The electro-galvanizing line is almost 500 feet long, and 40 strands of wire pass continuously through its 43,000 gallon electrolytic bath at speeds of from 35 to 70 feet per minute. The upper illustration shows the wire strands being pulled through sheaves of metal tubing into the lead annealing furnace before entering the zinc baths. The lower figure shows the wire emerging from the electro-galvanizing tank.

All machines are driven by lineshafts in sub-floor tunnels. This arrangement leaves the aisles between the machines clear for handling materials and products, and at the same time facilitates the oiling of the line-shafts and servicing the belts. Another unusual feature of this plant is that it is the only one in the country to use direct current electricity furnished by a mercury arc rectifier.

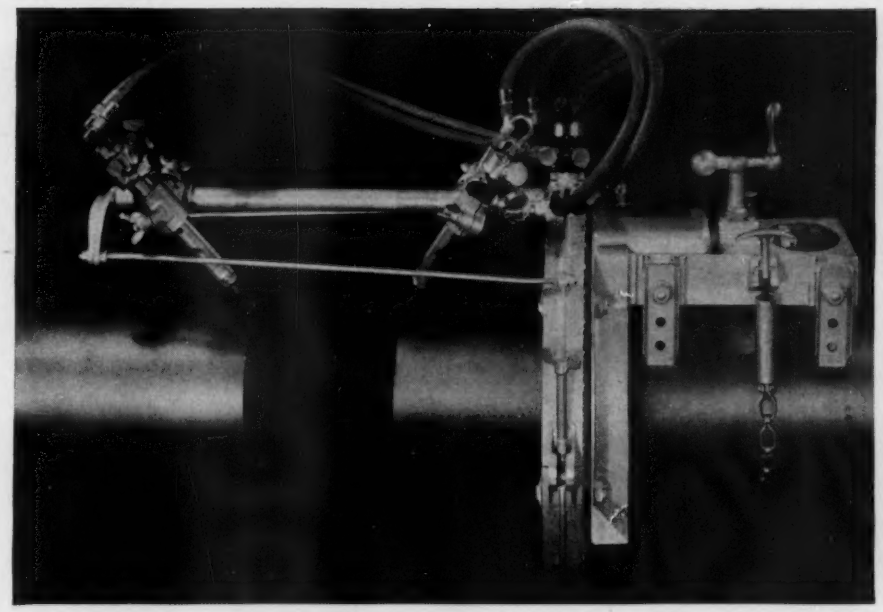


—Machinery.

OXY-ACETYLENE HARDENING

THE past decade has seen a considerable amount of research devoted to the investigation of the commercial and metallurgical phases of the now commonly called "flame hardening process." Flame hardening is the process wherein the surface of a ferrous material which can be hardened by quenching is subjected to an oxy-acetylene flame, followed by a suitable quench.

The four methods of flame hardening are (1) stationary, (2) progressive, (3) spinning, and (4) combination. In the stationary process, sometimes referred to as spot hardening, both blowpipe and work are held motionless during the treatment. The progressive operations utilize methods in which the lighted blowpipe and the metal move with respect to each other. The lighted blowpipe is directed along the surface at the maximum speed which will heat the surface zone above the critical temperature. Immediately behind the flame follows a stream or spray of water which progressively quenches the heated surface. The usual speed of the heating is between six and eight inches a minute. The tips of the inner cones of the blowpipe are kept at a distance of 1/16 to 1/8 inches from the surface being hardened. On circular work of a



large diameter, the blowpipe is held stationary and the work is rotated. The spinning method, used on rounds such as shaft bearing areas, rotates the work under the torch until the entire work has reached a hardening temperature, at which time the quench is applied while the work is still moving. If the diameter of the work exceeds four inches, blowpipes are mounted on opposite sides of the rotating work. The combination method incorporates the progressive and spinning methods and is applied to rounds of considerable area. The work is rotated before the blowpipe, which gradually traverses the piece longitudinally, being followed by a suitable quench.

Flame hardening requires oxy-acetylene apparatus of sufficient ruggedness and flexibility to function under severe operating conditions. The apparatus must be water-cooled and of sufficient gas capacity to treat an area of reasonable size in one operation. In small operations a stream of water from a round nozzle is sufficient to quench the area to be hardened. A fan shaped nozzle or spray is most suited to wider paths. The water pipe is best affixed to the blow pipe holder, and adjusted so that the quench should follow the last flame at a distance no closer than one inch.

In general, any steel that can be hardened by simple heating and quenching may be treated with the oxy-acetylene flame. The list of materials includes cast iron, alloy cast iron, all S.A.E. steels with more than 0.35 percent carbon, carbon vanadium, cromansil, and graphitic steel.

The principle advantage of the flame-hardening process lies in its ability to raise the temperature above the allotropic transformation temperature while the remainder of the steel body is, to all intents and purposes, unheated. The other slower methods always waste a large amount of heat in raising the temperature of the core, and therefore produce considerable internal stresses. As a result of the newer method, spalling, chipping, and similar difficulties are reduced. The speed of the flame-hardening process allows the hardening of outside layers as thin as 3/8th of an inch and possibly thinner.

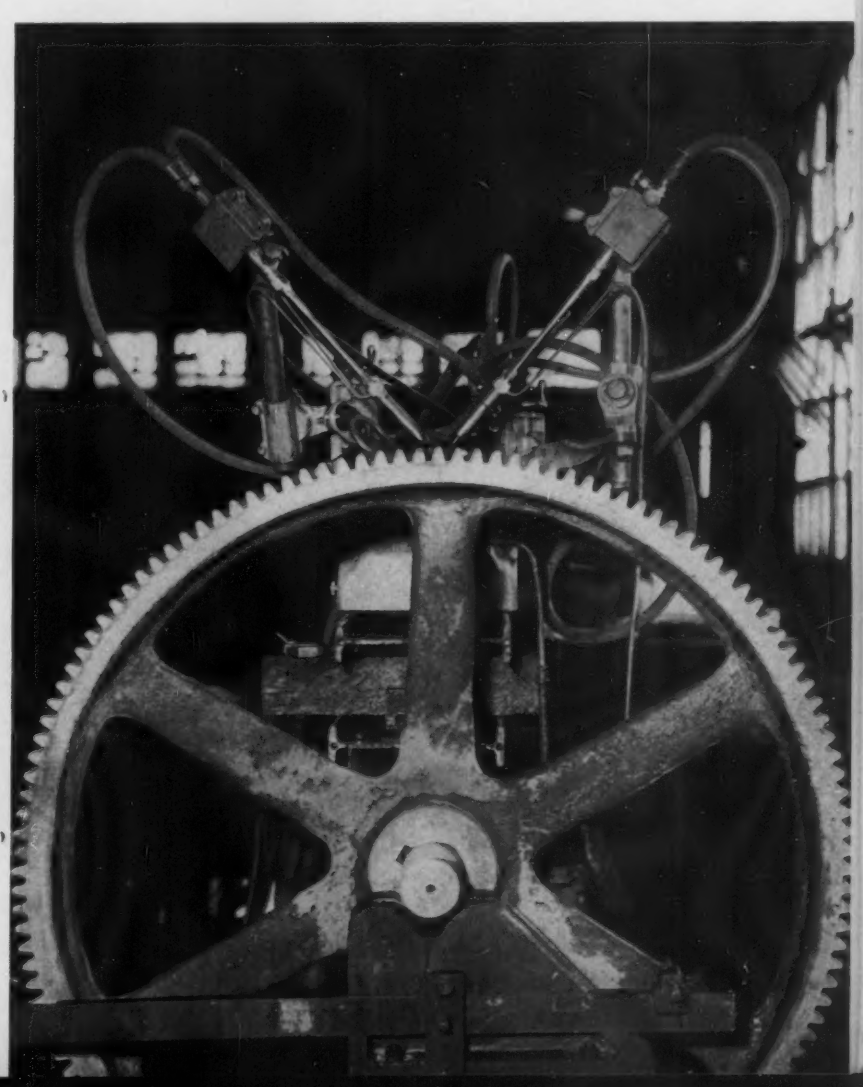
—Metal Progress.

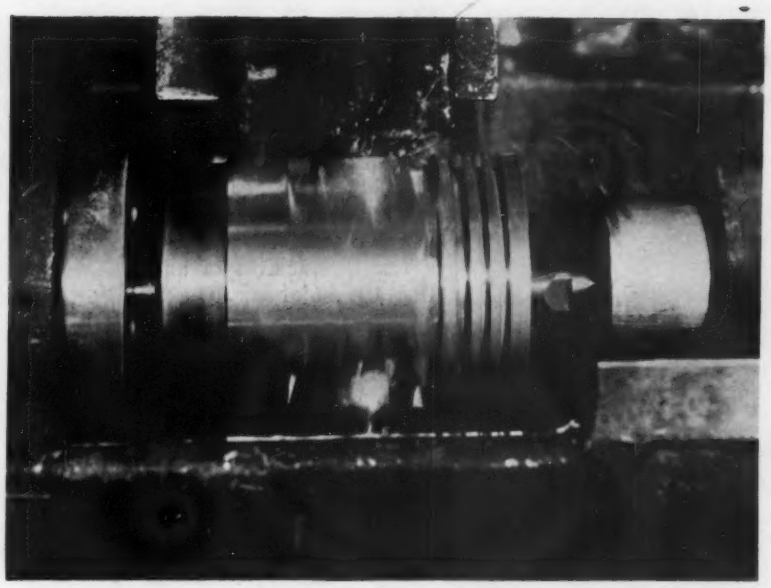
ELLIPTICAL GRINDING

A RECENT improvement in automotive pistons has been the use of elliptical instead of circular shaped pistons, with the minor axis of the ellipse through the pin bosses being only a few thousandths of an inch shorter than the major axis. The elliptical shape compensates for unequal radial expansion when the piston is placed in service.

Grinding is difficult with pistons having a split skirt because the locating centers of the grinding machine tend to spread the skirt. Pistons of this type are being ground in one large plant by using ten by eighteen inch Cincinnatti plane-hydraulic grinding machines. Two of these machines are used for rough grinding and four for finish grinding. Each machine is equipped with an "Ohio" cam attachment which adapts it for grinding ovals, and which replaces the standard footstock. The pistons are made of cast aluminum and are reinforced at the pin bosses by steel struts. A vertical slot in the skirt joins a cross slot under the third ring groove and permits the skirt to expand or contract freely.

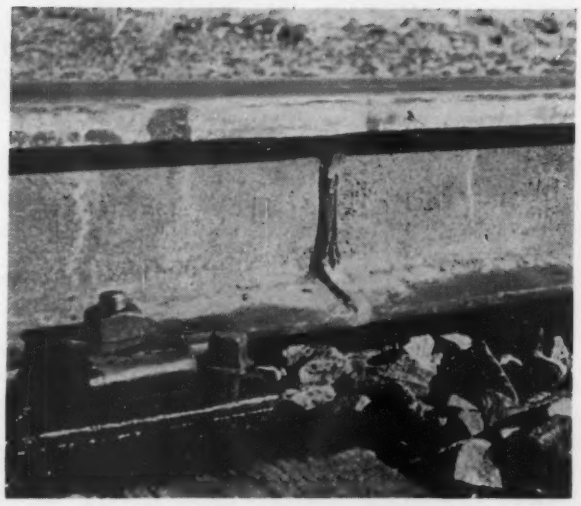
The piston skirt is ground to an ellipse by the in-feed or the plunge-cut method by a machine equipped with a grinding wheel three inches in diameter,which is the same width as the piston skirt. The accuracy of the piston profile at any point on the diameter must be within 0.0015 inch, and the skirt must be parallel with the center line of the piston from top to bottom, within 0.0003 inch.





The piston is withdrawn three eighths of an inch from the wheel and shifted slightly to one side at the end of each grinding cycle, to facilitate loading and unloading.

—*Machinery.*



ELECTRICALLY WELDED TRACKS

AN innovation in right-of-way construction, continuous rails, is being introduced by the Delaware and Hudson Railroad. Twenty rails of standard length are electrically welded together on a special construction train. These sections are then welded together by the Thermit process so that the track is continuous between insulated joints.

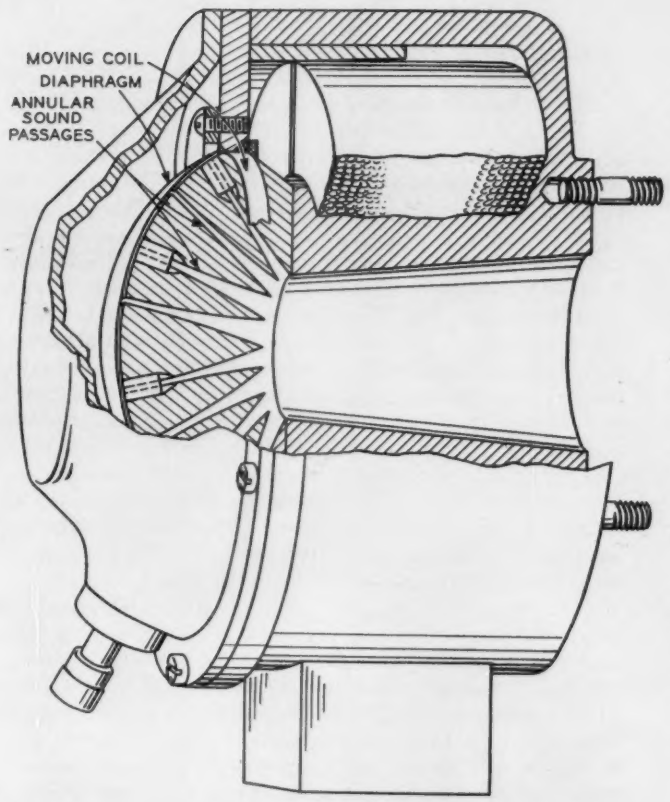
The equipment consists of a power car containing two steam-turbine driven generators, for which steam is supplied at the rate of approximately 20,000 pounds per hour by a road type locomotive, a rack car on which the rails are stored and prepared for welding, and a box car without ends which is used to house the welding outfit. The rest of the train is made up of flat cars with grinding and stress-removing equipment and storage cars for the completed sections.

The rail, after the ends have been cleaned, is transferred from the rack car to the welding car where electrical contacts are secured to the rails to be welded. The ends are heated to the fusing point by intermittent and then continuous short circuit. Hydraulic pressure fuses the ends. Stresses are removed by reheating the joint in an oil furnace, and offset metal is ground off in a series of grinders. In this way, as many as 166 joints can be made in a day. The early developments were made by the General Electric Co., while later developments and equipment have been made by the Sperry Rail Service, Inc.

—*Railway Electrical Engineer.*

DIPHONIC LOUDSPEAKER

MIRROPHONIC Sound is the name given to a recent sound picture reproducing system which gives aural effects approaching the clearness of a visual image. Pictured with this digest are the loud speakers named Diphonic because all the sounds below 300 cycles per second are fed into one unit, while those above 300 are carried by another. This sound distribution is accomplished by a crossover network, and the high frequency speakers are attached to a horn consisting of fifteen individual cells. Each of these cells tapers exponentially from five-eighths inch square at the small end to eight inches square at the flared opening. They are brought so very close together at the small end that only a knife edge separates them, while at the large end they are arranged as compactly



as the geometry of the arrangement permits. One of the biggest advantages gained from this multi-cellular construction lies in the fact that it makes the horn non-directional. The common single air-passage horn distributes sound uniformly over a wide angle at low frequencies but gives an undesirable concentration of sound on the axis of the horn as the frequency increases. For this reason persons sitting in line with or near the axis will hear too great a proportion of high frequencies compared to the low ones, while those seated at the sides will suffer from the inverse phenomenon. A uniform distribution of sound of all frequencies over a wide angle is the valuable asset of a well designed multi-cellular horn.

The technical aspects of this horn will prove of great interest at this point. The walls of the individual cells of the horn consist of two metal sheets with an intervening layer of felt all fastened together by a heat-softening cement. The completed assembly of the fifteen cells is accomplished by soldering, and the resulting walls show a high damping to mechanical vibrations, thus eliminating any possibilities of horn rattle. The cross section of the high frequency speaker shown above locates for you the important mechanical parts. A thin aluminum alloy diaphragm is attached to a cylindrical coil of many turns of aluminum ribbon wound on edge and held together by thin layers of varnish between adjacent turns. The diameter of the diaphragm has to be quite a bit greater than the wave length of the highest frequencies which it reproduces, in order that it will be able to deliver the required amount of sound energy to the horn. Coupling the diaphragm directly to the throat of the horn would greatly decrease the output at the higher frequencies because the phase of the sound coming from the various parts of the diaphragm would differ. These differences are eliminated by taking the sound from the diaphragm through several concentric annular passages so that the distance from any portion of the diaphragm to one of the passages is small compared with the wave-length of any sound transmitted.

A field coil wound for twenty-four volts provides the magnetic field for the air-gap of the high frequency speaker. This is the voltage generally used with theatre equipment. Safety features such as a cover over the field terminals and various factors for convenience in installation greatly enhance its satisfactory operation in the field.

The speaker systems previously used in the theatres have been surpassed in all respects by this new low-frequency speaker of the Diphonic system. The driving element consists of four dynamic speakers of the cone type connected in a vertical row to a shallow cavity which flares out to a flat baffle. In the cavity two tihn, vertical vanes are mounted between the post and the sides of the cavity to aid in the proper distribution of the higher frequencies radiated by the loud speaker.

The advantages of this loud speaker are good distribution of its higher frequencies, improved efficiency, and elimination of resonance effects which tend to distort the quality of the sound by unnaturally prolonging certai tones.

—Bell Laboratories Record.

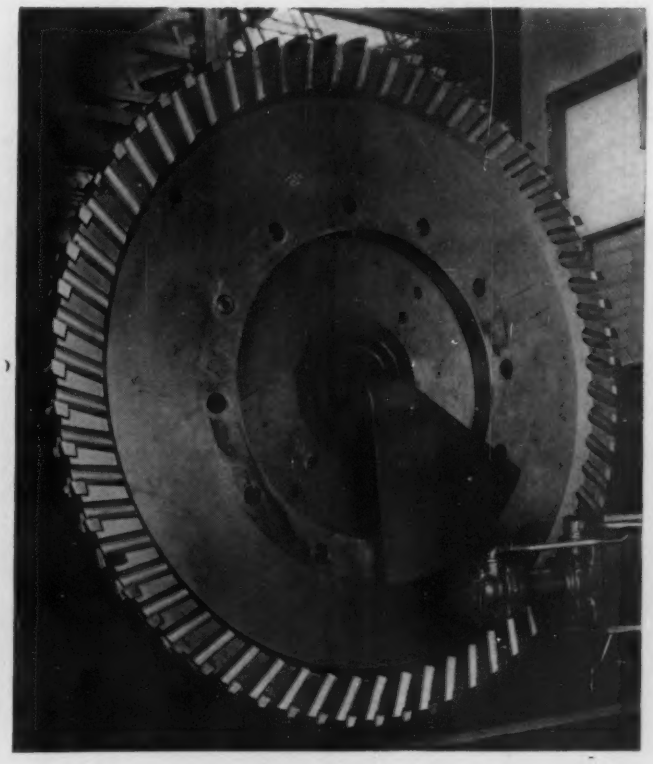
MAMMOTH CUTTING TOOL

ROLLING mill practice has advanced hand in hand with the metallurgical developments of recent years. For example, a manufacturer has developed a high speed cutter for aluminum that will simultaneously rough, finish, and mill a piece of stock at rates up to seventy-two inches per minute.

The cutter illustrated is of this type. It is sixty-eight inches in diameter and equipped with tungsten carbide cutting edges. It is driven by a 150 horsepower motor, and attains a speed of 3,000 revolutions per minute. The blades are set at rake and shear angles of twenty degrees. They may be removed for grinding and are reset by indicators on the cutter. The finishing blades, of which there are four against sixty roughing blades, have wide faces which will effectively sweep the surface. A soluble coolant is spread across the cutter by means of a fan shaped nozzle which projects from the center of the cutter spindle.

Cutters of the same type are made in fourteen and thirty-two inch diameters. These time and money saving machines are a perfect reflection in one field of advancements in another.

—Machinery.



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SUMMER SESSION BULLETIN

Educational Opportunities at the Massachusetts Institute of Technology

THE ENGINEER IN INDUSTRIAL RELATIONS

(*Continued from page 175*)

agreements, foreman training programs, profit sharing, etc. We expect to supplement this with samples of industrial relations material from the smaller companies in various sections of the United States, and we hope to build up a very complete record of material for the various New England industries. Similarly, on trade union we hope to collect information on their written agreements with employers and on whatever other activities they are willing to furnish information. A number of the more progressive trade unions have established or are now establishing research organizations of their own, and we shall endeavor to keep in close contact with their activities. Our library will also contain all the significant books and periodicals published in the field of industrial relations, and will be so classified and indexed as to be readily available for the use of business executives, labor officials, and research workers. The material will be used to answer specific inquiries from interested persons throughout the country.

As a research bureau the Section will prepare reports by means of correspondence and field investigations on labor problems of general interest. The range of subjects covered will include such questions as accident prevention, adjustment of disputes, age limitations, apprentice training, bonuses, child labor, collective bargaining, discharge, employee representation, employment methods, fatigue, hours, housing, insurance, job analysis, labor turnover, overtime, pensions, profit sharing, promotion, stock ownership, cooperative credit, unemployment, and wage determination. We plan to initiate our activities by making a survey of industrial relations practices in New England by industries. This will be undertaken by means of personal interviews and questionnaires. The information obtained on any particular company will be kept confidential if that is requested. With this background we should be in a better position to determine what special studies to undertake. The Section will also engage in research of a more fundamental character in the fields of economics, sociology and pyschology on questions affecting industrial relations. Such research will, in fact, constitute one of the major activities of the Section.

We hope that the Section will have important educational advantages to our students. All students at Technology take a general course in economics and many of them are required to pursue special studies in industrial relations. To have at hand a wealth of factual material, with specialists available for consultation, should be of great assistance in bringing the realities of employer-employee relations into the educational experience of Technology students. The project is in line with the recent trend in engineering education toward increasing the emphasis upon that larger network of human relationships in which the graduate engineer is necessarily involved.

Another activity of the Section will be an annual conference of company executives and staff members responsible for, or engaged in, industrial relations work. The conference now being conducted annually by the Princeton Section has been extremely popular and in recent years Princeton has had to turn away a large number of applicants. At Princeton, subjects of current interest in the field of labor have received consideration, using the method of brief presentations by qualified leaders followed by informal group discussions. The Princeton meetings have always been closed to the general public and have never been reported. While we expect to follow this precedent generally at M.I.T., we plan to open the evening sessions to the public.

In building up the staff of the Section we are anxious to bring together a group of men with varied background and experience. We feel this will enable us to obtain a greater un-

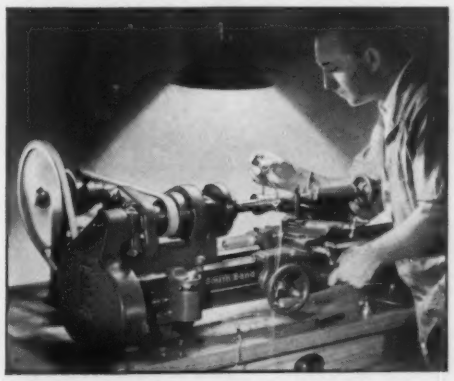
derstanding of industrial relations problems than if we had men who had specialized only in one phase of the subject. We have now on our staff connected with the Section, a sociologist and a psychologist, in addition to our regular economic staff. We are also anxious to strengthen the Section with men who have had very considerable experience in the field. In this connection we are particularly fortunate in being able to announce that by a special arrangement with the American Optical Company we have been able to borrow for a year, on a part time basis, Mr. Royal Parkinson, who has been personnel manager for that company for twenty years. He will be directly associated with the Section. We are conscious of the danger that a Section of this sort will fail to fulfil its function effectively if it does not succeed in keeping in constant close personal touch with practical experience in industrial relations. We are hopeful that by building up a group of research workers, who in addition to their academic background are thoroughly familiar with industrial relations as they are practiced today both in this country and abroad, our new Section will be in a position to be of real service to the community.

EDITORIALS

(*Continued from page 185*)

Formerly munitions were controlled mainly by individuals or corporations; but in recent years many governments have either partially or entirely taken over the munitions industries. Now, however, instead of selling for mere profits, as did individuals, the governments may sell munitions to other countries to stir up revolts and unrest, or may barter arms for needed raw materials. But the sad thing about the whole business is that munitions salesmen are so secretive, and have such fine connections, even among consular representatives and military attaches, that very few of their dealings can be brought to light. Consequently, it is impossible to know the havoc that the "angels of death" may be even presently wreaking.

Though we condone neither war nor extensive military preparations, we do think that the activities and discoveries of our own country might be kept secret. But no, some of our newest and most important secrets have been incorporated on a Brazilian warship in the Brooklyn Navy Yard, and it is a well-known fact that most governments do exchange secrets and information. It certainly does seem highly ironic to think of the possibility of having our own men killed by our own inventions and contrivances.



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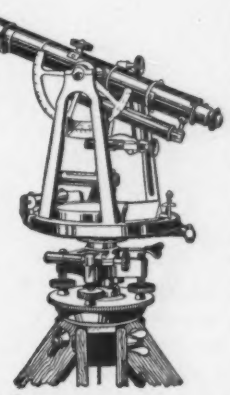

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IRON LUNG

(*Continued from page 179*)

sure, alternating with atmospheric pressure, was required; and that positive pressure was unnecessary except in unusual cases, because the elasticity of the chest itself causes exhalation during the intervals of atmospheric pressure.

The amount of negative pressure is customarily measured in terms of centimeters of water, and ranges from 10 cm. for young children to about 20 cm. for some adults. This consists, in other terms, of a lifting effect on the chest of from two to four ounces per square inch. The effect of this negative pressure, from the physiological standpoint, is to duplicate the action of the chest muscles and diaphragm in producing a subatmospheric pressure in the lungs. If the breathing passages are not mechanically obstructed, the pressure of the atmosphere causes the air to enter the lungs in a natural manner.

The original commercial respirator, which was made available in the latter part of 1929, was rectangular in shape, and was actuated by an electrically driven Roots pump, with a valve mechanism which alternately connected the pump to the chamber, and then vented the chamber to the atmosphere. This was effective and quite reliable, but had the disadvantage of being noisy, and became quite a problem when a patient required treatment for periods of days, weeks, and months. For that reason, a quiet operating unit was developed, consisting of a large bellows, built onto the chamber. This bellows was actuated by an electric motor through a reduction gear, crank, and lever. Expansion of the bellows reduced the chamber pressure periodically at any desired speed. Pressure was controlled by means of a variable vent, which allowed inward leakage sufficient to limit the pressure to any point for which it was set.

Besides quietness, this mechanism had other advantages. It enabled the limitation of the chamber pressure to a safe maximum, through the proper proportioning of the volume displacement of the bellows in comparison with that of the chamber. Further, it enabled provision for emergency operation by hand in the event of power supply failure or motor trouble.

Present models of the Drinker respirator are made with a cylindrical form, partly to facilitate manufacture, and partly to reduce the weight and improve portability. This latter factor did not seem particularly important at first, because the inherently bulky nature of the machine seemed to restrict its applications to permanent installation, as in the hospital field. However, the need for greater portability has arisen in connection with the delivery of respirators to points where they have not been available before, and where the need for one has suddenly arisen.

In such cases, it becomes a question of whether to take a patient to the nearest available respirator, or to try to maintain life until a respirator can be delivered. Neither is a satisfactory solution, and the history of respirator demand has been largely one of sporadic peaks, which coincide with infantile paralysis epidemics, and during which the manufacturer is frantically expected to foresee and meet the emergency. Despite intensive educational efforts, it has been impossible to achieve a stable demand which would make possible economical and efficient manufacture.

Occasionally the question is raised about shipment of a respirator by airplane. That this is not beyond possibility is shown by the fact that early in October of this year, not only was a respirator transported by plane from Wichita Falls, Texas, to Tulsa, Oklahoma, but on the return journey, the respirator had in it a 15-year-old girl who depended on it entirely for her breathing. Of course, this respirator was hand-operated while in the air. In order to accomplish this feat, it was necessary to employ a huge U. S. Army Bellanca bomber, permission to use which was granted by the President. Present-day commercial planes, though having carrying capacity sufficient for a respirator, do not have adequately large entrance hatches. Present standard respirators weight about 475 pounds, and are 6½ feet long, 28 inches wide, and 5 feet high.

New types of respirators are now available which improve the facilities for the care of the patient. One of these enables elevating the foot end, and tilting the bed to either side, to afford greater comfort and to promote drainage of the respiratory passages. This helps to avert the possibility of pneumonia caused by the accumulation of fluids at a single point in the lungs. Another form has, in addition to the foregoing features, an enlarged "head end" which allows the use of special splints for the arms, to give greater rest to affected muscles.

Perhaps the ultimate form of the Drinker respirator is the respirator room, of which the only one now in existence is located at the Children's Hospital in Boston. This consists of a steel chamber or "room" large enough to accommodate four cots, arranged "upper and lower" fashion, with working space between. The patients lie on these cots, as in a standard respirator, with their heads protruding outside the room through the familiar rubber collars. The air pressure inside the chamber is changed as in a regular respirator, by means of a large-capacity turbine pump, equipped with an alternator valve similar in function to that of the original respirators. The location and acoustic treatment of the actuating unit are such that no noise reaches the room.

The biggest advantage of the respirator room is that it enables complete access to the patient's body for examination and treatment, since both doctors and nurses can be inside the room while it is in operation. The only sensation noticed is the fluctuation of pressure on the ear-drums, which is so slight that it is not dangerous or even objectionable.

The respirator room is probably superior in its contribution to the comfort and the ease of care of the patient, even to the "new" type of respirator which has received considerable publicity recently, and which operates on somewhat the same principle as the Drinker respirator, except that it has a chamber covering only the chest and upper part of the abdomen. As a matter of fact, a device of this kind had been developed in Europe a short time before Professor Drinker developed his respirator; and although the former device has been in existence for nearly 10 years and was patented in this country in 1928, it has made little progress in the treatment of the respiratory paralysis of poliomyelitis. This is probably because it is mechanically difficult to devise a single chest unit which would accommodate all sizes and shapes of persons, and which would be both leak-proof and comfortable for extended periods. The Drinker respirator has no limitations in this respect, as is evidenced by the fact that not only has it broken all records for prolonged artificial respiration, but it has safely carried its most publicized patient, Mr. Frederick Snite, Jr., from Peiping, China, to Chicago, Illinois, and most recently from there to Florida, where he is continuing the plucky fight for recovery which he began nearly two years ago in China.

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EDITORIALS

(*Continued on page 193*)

Experience, it is said, is the best teacher, but in the light of man's past history this statement seems particularly doubtful, for no less than twenty years after the greatest catastrophe the world has known, we are making the same mistakes again. Therefore, the truth must be driven home to all individuals that, despite the fact that munition manufactures may cause a superficial prosperity, they inevitably lead to war. The aftermath of each war has been not only untold oppression and heartbreak, but also a severe depression, which leads once again, in the same vicious circle, to another war. Germany is a striking example of the previous statement.

Under the present circumstances, with dictatorships dotting the earth, the cure of the munitions ailment is most difficult. It remains for the democracies, if they are to exist, to do something to alleviate the festering sore that seems ready to engulf the world. An enlightened public opinion, through proper education, can force legislation that will give the government greater control over the activities of munitions makers. Further, laws must be passed to bring their submerged artifices into the light, for secrecy has ever been their need. If we can prevent the subterranean dissemination of arms to the troublemakers, much will be gained, for these same troublemakers are those who most lack the money and materials for carrying on war. The engineer or scientist can do his part to avert the Armageddon, which undoubtedly approaches, for he is in a position to educate those who lack knowledge. Moreover, he holds the key to further inventions and to the exploitation of present methods, which, otherwise, might be harmfully used.

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ELECTRONICS IN MUSIC

(*Continued from page 177*)

coördinates. The constants of each equation are regulated so that when plotted on a piece of cardboard or similar material, the amplitude will correspond to the allotted width of track on the disc, and the inside border of the resulting curve will be of the same radius as the inside of the particular track on which the recording is to be made. The cardboard is carefully cut along the curve, and the resulting template rotated between a light beam and the revolving disc, which has been photographically sensitized. The ratio of the speed of the template to the speed of the disc is adjusted so that a desired number of waves are recorded on the complete circumference of the track. In practice, all of the octaves of any given note of the musical scale are recorded in three different tone colors on one disc. Figure 3 shows a sector of one of these dics, and a careful study of it will facilitate the understanding of the foregoing explanation. Rings 1, 2, and 3, as will be seen by inspection, are three low octaves of one tone color, one being the lowest octave, and three the highest. Rings 4, 5, 8, 11 ,and 14 are five octaves of one tone color; 6, 9, 12, 15, and 17 are five octaves of another; and 7, 10, 13, 16, and 18 of yet another.

The method explained here is the one developed by Prof. Hardy and his associates some seven years ago. There was no information immediately available concerning the exact method used by Mr. Welte, but there is good reason to believe that it is essentially the same.

In the *Photolone*, as in the *Hammond*, twelve different speeds are used—one for each note of the scale. A disc revolving at one speed produces all of the C's of three different tone colors, and another exactly like it revolving at another speed produces all the D's of the same three tone colors. The smallest model of the *Photolone* has six different tone colors available. Thus, there are two discs revolving at each of the twelve speeds, each disc of a pair producing three tone colors. Each disc has its own assembly of photo cells and lamps.

One of the drawbacks of the *Hammond*, the lack of a number of higher harmonics, is also present in the *Photolone*. In the case of the *Hammond*, as previously explained, these harmonics are not supplied by the tone mixing system. In the case of the *Photolone*, however, they are lost in the various stages of recording—first, in the taking of oscillograph records, second, in the mathematical analysis of these records, and third, in the actual recording process. A glance at Figure 3 will illustrate this. Certainly the wave forms pictured there do not show any of the complexity which is introduced by a large number of harmonics. Thus, the tones produced lack some of the richness and fullness of those from which they were originally recorded. Another disadvantage of the *Photolone* is that the tone-producing equipment takes up considerable space in comparison with that required by other electrotones.

The last of these electrotones differs somewhat from the others in that the tone producing elements are harmonium reeds, operated by wind pressure as is an organ. The inventor is Mr. Fredric Albert Hoschke, and he has named his instrument the *Orgatron*.

During the nineteenth century the "reed organ" or "harmonium" was a familiar sight in many thousands of homes. The tones of the harmonium are produced by reeds made of horizontal strips of brass, fastened at one end and weighted on the other. These are vibrated by air being drawn over them into a vacuum reservoir, which is kept exhausted by a

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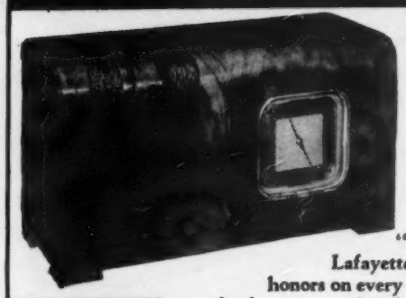

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pair of bellows operated by foot-pedals. In the *Orgatron* a set of these reeds (sixty-one of them, five octaves) is used for each tone color desired, and the vacuum reservoir is kept exhausted by a centrifugal fan. Instead of letting the reeds be heard directly as they are played, however, they are enclosed in sound-proof boxes. Each reed is in a small cell by itself, and over it is a small horizontal disc, whose distance from the reed can be regulated by a screw to which it is attached. All of the reeds are attached to a common ground, and the discs (tone screws) for each set of reeds are connected together and a polarizing voltage applied between all of the reeds of a given set and their tone screws. When any reed is set into vibration by depressing its corresponding key on the keyboard, it acts exactly like a condenser microphone, and the electrical effect thus produced is amplified by electrical equipment similar to that of the *Hammond*. Since these reeds are very rich in harmonics, proper regulation of the tone screw, both for size and distance from the vibrating reed, and proper adjustment of certain factors in the amplifying circuit will, by removal of unwanted harmonics and amplification of desired harmonics, produce different varieties of tone color. Here the tonal disadvantages of the *Hammond* and *Photolone* are fairly well eliminated, for the harmonics are *natural* (fundamental and harmonics for any given tone being produced by the same reed), and there is a good supply of them to draw from.

Inherent in all of these electrotones, of course, are certain limitations imposed by electrical amplification and by loud speakers. Mr. Hoschke makes one good point on the subject, however:

"If the reader thinks of these as reproducing units, as in radio, he may be justified in assuming that electronic tone-production success is directly proportionate to speaker efficiency, or characteristics. If, however, he will regard the speaker (as used in the *Orgatron*) not as a reproducing unit, but as a part of the tone-producing system—he will have a less prejudicial regard for the use of these units in the new art."

Why is an electrotone? Why do these imitations of the organ exist when we have real organs? These questions quite naturally arise, and there are several answers to them. First and foremost are the factors of cost, space required, ease of installation, and portability. In all of these the *Hammond* and the *Orgatron*, and possibly the *Photolone*, have an advantage over the organ. The cost is in the neighborhood of that of a good grand piano, the lowest priced models selling for around $1300. While small pipe organs may now be purchased for even less than this, the electrotones still have the advantage in ease of installation, the small space required, and portability. The tonal flexibility (variety of tone color obtainable) of these small organs is not very great, but their tone *quality* is decidedly better—and why shouldn't it be?—the original is usually better than the imitation. A general summary of advantages and disadvantages here will help the reader to gain a better conception of just what these electrotones do amount to.

Consider first the *Hammond*. Here a continuously variable range of tone color is at the disposal of the player. Limits are imposed by lack of sufficient harmonics to produce full, rich tones, and the failure of certain of the harmonics to "jibe" with their fundamental. In the case of the *Photolone*, we have somewhat less tonal flexibility, with elimination of the disadvantage of dissonant harmonics. There is still the inherent lack of richness and fullness, and the additional disadvantage of large space requirement. In the *Orgatron* the tonal flexibility is comparatively smaller, but the tone itself is more real, rich, and satisfying. Mechanically, the *Hammond* and the *Photolone* are probably more foolproof than the *Orgatron*, since the latter involves considerable use of wood and leather parts (nearly always necessary where air pressure is involved

(*Continued o n page 198*)

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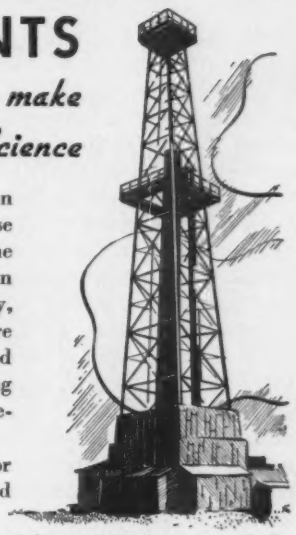

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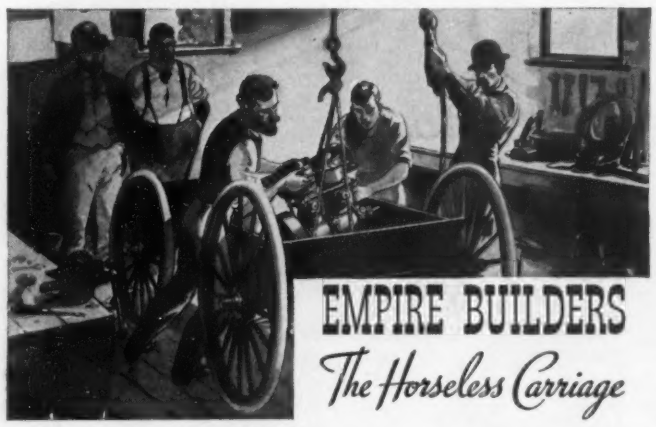
ELECTRONICS IN MUSIC

(*Continued on page 197*)

in the generation of tone). Another consideration is that the action of the *Hammond* and the *Pholotone* is instantaneous. When a key is depressed, sound emanates from the speakers simultaneously. In the *Orgatron*, a fraction of a second is required for the reed to get into vibration, and this delay is noticeable when one plays a fast piece of music.

Another feature of electrotones in general might be brought in here. In the organ, the pipes are generally enclosed in a box or chamber having a set of shutters on one or more sides. These shutters may be opened or closed, or left in any intermediate position at the will of the organist, by a balanced pedal of the console. Thus the volume of the organ may be continuously regulated over a limited range. In the electrotone, a similar pedal on the console is attached to some sort of gain control, usually in the pre-amplifier circuit, and the volume flexibility of this gain control is practically from zero to maximum. The organist, therefore, has under the control of his foot quite a tremendous range of power—"from a whisper to a blast," as some of the advertising matter puts it—and it is no small thrill, especially for the amateur, to have absolute control over such an amount of power as one plays the instrument. The dynamic range of the "swell pedal" of the electrotone is, in general, about three times as large as that of the organ swell pedal.

In the final analysis, the relative merits of these electronic instruments are mostly a matter of what the buyer wants for his money. The possibilities of the field which these instruments represent are still to be exploited, and the future may bring us entirely new experiences in music from this direction. Whether or not these experiences will amount to anything worth while will depend on the men who choose to investigate the field and what they accomplish.



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EMPIRE R B & W

WELDING OF ALLOY STEELS

(*Continued from page 182*)

greater thicknesses in the 0.20 percent carbon grade a special high strength rod is required. If welds are made in grades containing more than approximately 0.20 percent carbon, a normalizing treatment is necessary to insure adequate ductility in the welded joint.

Cor-Ten steel is a ductile low carbon, chromium-copper-silicon-phosphorus steel with a yield point approximately twice that of mild steel, and an atmospheric corrosion resistance 4 to 6 times that of ordinary open-hearth steel. The physical properties of Cor-Ten are as follows:

Yield Point, Lb./sq. in.	= 50,000 minimum
Tensile Strength, Lb./sq. in.	= 70,000 minimum
Elongation, percent in 8 inches	= 1,500,000/Tensile Strength
Impact, Charpy, Ft. Lb. (average as rolled)	= 40
Endurance Limit, Lb./sq. in. (normalized)	= 45,000

With low carbon and alloy content, the steel is subject to but little air-hardening, hence preheating is not generally required. The alloy is readily welded with high-grade shielded metal-arc electrodes. Typical values for weld metal deposited by mild steel electrodes will fall in the following ranges:

	As Welded	*Stress Relief Annealed at 1200° F*
Yield Point, Lb./sq. in.	45–60,000	40–50,000
Tensile Strength, Lb./sq. in.	60–75,000	55–65,000
Elongation, percent in 2 inches	30–20	35–25

When mild steel electrodes are used on Cor-Ten steel, a certain amount of the melted base metal is mixed with the deposited metal. The extent to which this mixing takes place depends on the type of joint and upon the metal on which the welding bead is deposited. If deposited wholly on Cor-Ten base metal (as in a single pass weld or the first bead or layer of a multiple-pass weld), the mixing will be considerable. On the other hand, if superimposed on previously deposited layers of weld metal, the intermixing will become progressively less. In single bead welds, therefore, values approaching the upper limits may be used. In large multiple-bead welds, the lower values will be obtained. The use of bare wire electrodes is not recommended with Cor-Ten, since they are apt to produce porous welds with inferior ductility. The oxy-acetylene process will produce satisfactory welds if a high strength welding rod is used.

Man-Ten is a steel containing manganese as the alloying element in combination with carbon. This grade of steel, with its high strength and good abrasion resistance, is particularly suitable for parts subject to high working stresses. Its physical properties are given below:

Yield Point, Lb./sq. in.	= 50,000 minimum
Tensile Strength, Lb./sq. in.	= 80,000 minimum
Elongation, percent in 8 inches	= 1,500,000/Tensile Strength
Izod Impact, Ft. Lb.	= 40
Endurance Limit, Lb./sq. in. (normalized)	= 40,000

The chemical composition of this alloy is such that some degree of air-hardening may result from welding. The undesirable effects of air-hardening will decrease as the thickness of the metal decreases, and in thin sections, say, 3/16 inch or less, the increased hardness is of relatively little importance.

(*Continued on page 199*)

WELDING OF ALLOY STEELS

(*Continued from page 198*)

When welding heavy sections, preheating to a temperature of 350° F (the melting point of 50–50 solder) will satisfactorily reduce the quenching effect of the cold mass of base metal. Similarly, preheating should be used when flame cutting thick sections to avoid hardening next to the cut edge.

Man-Ten steel is readily welded with ordinary, high grade shielded metal-arc electrodes. In joints where 100 percent efficiency is required, higher strength electrodes, such as Carbon-molybdenum, may be used, which will produce welds having physical properties comparable in every respect to the base metal.

To increase the ductility of the welded joint, annealing at 1150–1250° F, after welding is recommended wherever this procedure is feasible.

From the standpoint of weldability, these steels whose alloy content is 5 percent or more can be called high-alloy steels. They comprise chromium, chromium-nickel, and Hadfield manganese steels.

It will be convenient to discuss the chromium and chromium-nickel alloys as a group. Certain alloys of chromium and iron, with or without nickel, combine unusual resistance to corrosion with very desirable physical properties. These are the steels which are commonly referred to as "Stainless Steels." The straight chromium alloys, martensitic or ferritic at ordinary temperatures, are magnetic, and, depending upon carbon and chromium, may be hardened by heat treatment. The addition of eight or more percent of nickel causes the alloys containing more than about 16 percent Chromium to retain an austenitic form at room temperatures, and hence they are non-magnetic. Furthermore, they can not be hardened by heat treatment, although cold working markedly increases their strength and hardness.

The following table shows the chemical composition and physical properties of typical weldable alloys:

Chemical Composition	*5 Chrome*	*12 Chrome*	*17 Chrome*	*27 Chrome*	*18 Chrome 8 Nickel*	*25 Chrome 12 Nickel*
Chromium %	4–6	12–14	16–18	25–30	17–20	22–28
Nickel %	—	—	—	—	8–12	12–16
Carbon % max.	0.15	0.10	0.10	0.10	0.15	0.25
Manganese % max.	0.40	0.50	0.50	0.50	0.50	—
Silicon % max.	0.40	0.50	0.50	0.50	0.75	—
Physical Properties						
Yield Point, Lb./sq. in.	35–40,000	35,000	40,000	50–60,000	35–45,000	40–60,000
Tensile Strength, Lb./sq. in.	65–70,000	65,000	75,000	75–90,000	80–95,000	90–110,000
Elongation, % in 2 inches	40–35	35	27	30–20	60–55	50–35
Reduction of Area, %	75–65	65	55	60–50	65–55	60–45

4–6% chromium steel, while not stainless in the true sense of the word, is used extensively in the petroleum industry or wherever resistance to scaling and oxidation are required for long periods at high temperatures. For severe service applications, a popular modification contains a half percent or more of molybdenum, or a small addition of titanium.

The most important characteristic of 4–6% chrome steel, as far as welding is concerned, is its marked air-hardening tendency, which increases with both carbon and chromium content. For this reason, the carbon should be as low as practicable. Preheating to about 450° F is essential in all but the

(*Continued on page 200*)

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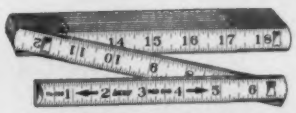
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WELDING OF ALLOY STEELS

(*Continued from page 199*)

lightest gages and, as soon as possible after welding, the structure should be annealed by heating to about 1575° F, and furnace cooled to 1200° F, or reheated to 1300° F for several hours depending on the thickness.

The electrodes or welding rods may have an analysis similar to that of the base metal (usually a small excess of chromium is provided) or a rod of much higher alloy content (18% chrome — 8% nickel) may be used. The latter filler metal should be used with caution because of its higher coefficient of expansion and its susceptibility to intergranular corrosion following the heat treatment recommended for this alloy.

12% chrome steel is a true stainless steel. It is intensely air-hardening, consequently the weld and adjacent zones will be hard and brittle. This condition, however, may be modified by small additions of titanium, columbium, or aluminum, or by a suitable anneal after welding.

Electrodes should be of the same or slightly higher alloy composition than the base metal. The use of austenitic filler metal (18% chrome — 8% nickel) is not recommended on account of differences in corrosion resistance. Gas welding may be employed provided non-hardening compositions are used, and provided that a strictly neutral flame is maintained to avoid carburization.

For best practice the treatment after welding consists of heating uniformly and slowly to 1450°–1500° F and soaking thoroughly. This should be followed by slow cooling at a rate not to exceed 50° F per hour until black, after which the rate of cooling is immaterial. Unless such a heat treatment is possible, it is not advisable to weld this alloy if it is to be subject to shock in service, since straight chromium welds are brittle in the as-welded condition when cold.

From the standpoint of welding, both 17% and 27% chrome steel have similar characteristics. Grades containing up to about 0.15 carbon are essentially non-hardening. Sound welds can be produced, but the heat of welding develops a coarse crystalline structure which cannot be corrected by any subsequent heat treatment. Consequently the welds and adjacent base metal are extremely brittle and may crack at room temperature. However, the ductility is so improved at temperatures above 400–500° F that welded structures are extensively used at elevated temperatures with excellent results. The 17% chromium steel is quite generally used for service up to about 1550° F, and the 27% chromium steel in temperatures from 1500 to 2100° F. In the case of 15–17% chromium steel, a special heat treatment following welding is sometimes employed when the structure is to be used at room temperature.

Preheating is recommended for both grades of steel. High grade electrodes or rods of the same composition or of slightly higher chromium content should be used. If greater ductility in the weld metal is required, the austenitic compositions (18% chrome — 8% nickel, or 25% chrome — 12% nickel) will be found satisfactory. It must be kept in mind that when these latter grades of filler metal are used, difficulties may arise due to differences in expansion coefficients and corrosion resistance.

Annealing should always follow welding. The treatment is to hold at 1350–1600° F (the temperature depending on the composition) for about one hour per inch of thickness, and cooling rapidly. For the 27% chromium steel, quenching should be employed if possible.

Austenitic stainless steels (18% Cr–8% Ni and 25% Cr–12% Ni) are the most important and useful of the stainless group. They combine high tensile strength and great ductility with toughness, and possess highest corrosion resistance. They do not become brittle as a result of the welding heat. They do not air harden, hence weld metal on cooling will have essentially full ductility. The tensile strength can be doubled, and the yield point of thin sections can be increased as much as five times by cold working, such as cold rolling or forming. Their superior properties, both stainless and physical, have found wide application in architectural work, in moving structures, such as light-weight railway trains, and in countless industries, such as dairy, food, and chemical, where cleanliness and freedom from corrosion are critical.

They have one peculiar characteristic. If these stainless steels are heated, during welding or other fabrication, to temperatures in the range 900–1500° F a precipitation of chromium carbides occurs at the boundaries of the grains. The magnitude of this precipitation depends on the carbon content and the time in this temperature range. The resulting depletion of chromium adjacent to the grain boundaries lowers corrosion resistance. This condition may be avoided either by keeping the carbon content below about 0.06%, or by small additions of other elements, such as titanium or columbium, in which case no trouble arises. Those steels which contain these added elements are called "stabilized." If stabilized steels are not used, the effects of carbide precipitation can be completely avoided by suitable heat treatment after welding (consisting of heating to 1650–1900° F, depending on composition, holding at temperature until the piece is heated thoroughly and uniformly, and then followed by extremely rapid cooling or quenching).

If these steps be taken, excellent welds can be made with the electric arc, oxy-acetylene flame, atomic hydrogen, and all forms of resistance welding. In fusion welding processes the filler metal should be of the same composition as the base metal. In resistance welding, the high electrical resistance of these alloys makes it possible to complete the weld in so short a time as to prevent any harmful carbide precipitation. High current for extremely short time (sometimes as short as 1/20 second) has been found most effective.

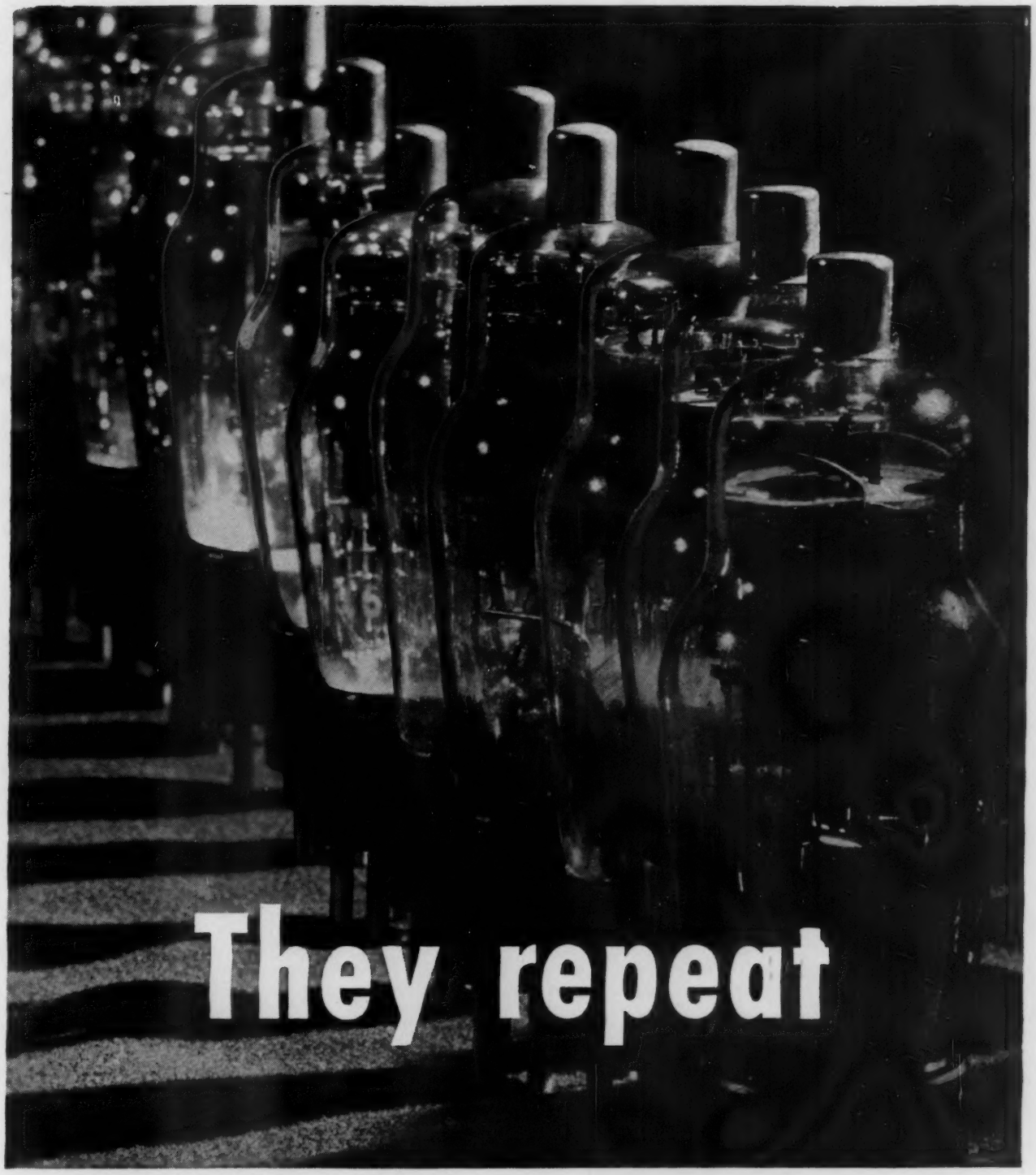
Austenitic Manganese Steel, discovered by Hadfield in 1882, owes its unique place in industry to its remarkable abrasion resistance. It is used for railway crossings, switches, and frogs, and to resist the heavy wear involved wherever hard materials are to be dug, crushed, or handled. The steel contains 11–14% manganese with 1.0–1.4% carbon. When slowly cooled, the steel is quite brittle, but when properly heat-treated (heating to 1830–1940° F followed by quenching), it has the following properties:

Proportional Limit, Lb./sq. in.	= 40–60,000
Tensile Strength, Lb./sq. in.	= 130–160,000
Elongation, percent in 2 inches	= 70–60
Brinell Hardness	= 230

While the hardness in the treated state is fairly low, cold working or abrasion rapidly increases the hardness up to 450–550 Brinell. It hardens extremely rapidly, and it is this property which makes it so useful.

Special precautions must be taken when welding this grade of steel. Filler metal should be used having a composition of 13–15%Mn, 3–5% Ni, and about 0.60–0.80% carbon. The nickel toughens the zone adjacent to the weld, which is the place where failure would occur if filler metal were used of the same composition as the base metal. Neither the base metal nor the weld metal should be overheated.

Information on welding technique has been omitted from this article. Such details as electrode size, current strength, gas pressure and tip size, methods of depositing beads or layers, preparation of the joint for welding, and similar data, for specific cases may be found in publications devoted to welding, such as the *Journal of the American Welding Society*.



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Without repeater tubes, which amplify voice currents every 50 miles, telephony over very great distances would hardly be possible. ¶ Incidentally, the telephone repeater tube was one of the first applications of the vacuum tube principle, which now makes it possible for you to talk across the continent as easily as just around the corner. ¶ Changing needs call for continuous telephone research to make your service more and more valuable.

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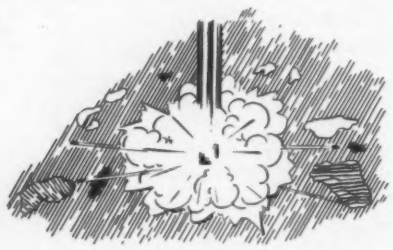
G-E *Campus News*

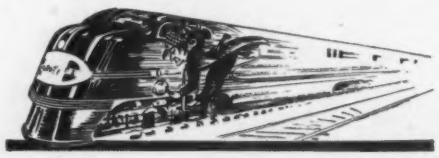
SHARPSHOOTING TWO MILES UNDERGROUND

SHOOTING HOLES through an oil-well casing at a depth of two miles underground is another problem successfully solved by electricity. The Lane-Wells Company Gun Perforator is an ingenious device used to pierce casings with steel bullets. When an oil pocket has been exhausted, the operators pierce the well casing at a different stratum, thus opening another pocket.



In order to know where to pierce the casing and how deep the gun is, G-E electric locating, weight, and depth instruments are mounted on a panel in a truck from which the shots are fired and the results recorded. Over two and one half miles of steel-sheathed cable is used to lower and fire the gun, the current for the charge being carried in the core of the cable. Accurate measurement of the depth at which the gun strikes or leaves the fluid level in the well is indicated to the operator by a weight indicator which utilizes two General Electric Selsyn motors.

In General Electric Company, numerous groups of engineers devote their entire time to the most efficient use of electricity in all types of industries. These men, former members of the Test Course, have solved many problems such as Sharpshooting Two Miles Underground.

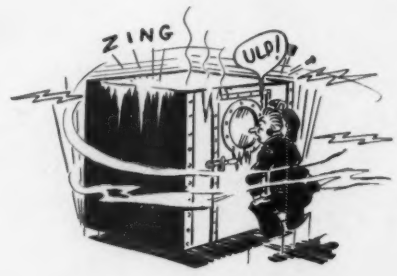


TRAIN-PERFORMANCE DETECTIVE

IN AN EFFORT to determine more accurately the performance of an electric locomotive and to calculate the most efficient motor for the train, T. F. Perkinson, R. P. I., '24, a former Test man now in the Erie Works of General Electric Company, invented a machine which performs these operations mechanically.

Computation by the step-by-step method of these calculations necessitates many hours of tedious slide-rule work; repeated adding and subtracting of time, speed, and distance increments; and reading of charts. The Transportation Calculator eliminates this work and solves the mathematics at least five times as quickly, depending upon the skill of the operator.

The Transportation Department of General Electric Company offers many opportunities to mechanical and electrical engineers in the design, construction, and production of electric locomotives, trolley cars, and trolley buses. The solutions of many interesting problems are found in this department, the Transportation Calculator being but one of them.



BOXING THE ELEMENTS

WIND, RAIN, SLEET, SNOW, arctic and tropical temperatures, six-mile altitudes, and power dives—all are found within the confines of two steel rooms in the radio-transmitter test department in the Schenectady Works of General Electric Company.

To assure perfect performance of aircraft transmitters, the equipment is placed in these two rooms where extremely severe weather conditions are simulated. Portholes of one-inch glass in the rooms permit the test men to observe the effects on the instruments without being subjected to the same strains placed upon the transmitters.

These complicated tests are made by college-trained men now on Test. The field of radio transmission from airplanes is, of course, new and progressive. The "flight rooms" provide radio engineers with a new and clearer conception of designs for radio equipment.

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